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Effect of Blended NPS Fertilizer Supplemented with Nitrogen on Yield Components and Yield of Maize (*Zea mays* L.) in Kachabirra District, Kembata Tambaro Zone, Southern Ethiopia

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Abstract – **Maize is one of the major and an important cereal crop in Ethiopia. However, the yield of the crop is low mainly due to low soil fertility problems. Therefore, a field experiment was conducted to assess the effect of blended NPS fertilizer supplemented with inorganic N on maize yield components and yield and to determine the economically optimum levels of NPS and N required to obtaining higher yield of maize. Factorial combinations of four levels of NPS (0, 100, 150 and 200 kg ha-1) each supplemented with five levels of N (0, 23, 46, 69 and 92 kg N ha-1) were laid out in a randomized complete block design with three replications. The results of the soil tests revealed that most of the chemical properties of the experimental site were indicative of low fertility status. Almost all parameters were significantly affected by the main effect of NPS and SN, except number of kernel rows per cop. The maximum (80.00 and 80.67) days to silking were obtained due to 200 kg blended NPS ha-1and 92 kg SN ha-1, respectively. Similarly, the interaction of NPS with N rate had significant effect on all parameters, except days to silking and number of kernel rows per cop. The highest grain yield (8680 kg ha-1) and highest harvest index (43.96%) were obtained from application of 200 kg NPS ha-1 with 92 kg of SN ha-1 as well as the highest number of kernels per cob (614.0) and the highest 1000-kernels weight (441.7g) were obtained at the combinations of 200 kg NPS ha-1 and 92 kg SN ha-1. The results of the economic analysis showed that the maximum net return (1107.56%) was obtained due to the application of 200 kg NPS ha-1with 92 kg N ha-1. In conclusion, the results of the study showed that application of 200 kg blended NPS ha-1 with 92 kg N ha-1 enhanced yield of maize with acceptable economic benefit. However, the experiment was carried out only in one location for one cropping season, so further studies at different locations for several seasons is needed to recommend agronomical optimum and economically feasible levels of NPS and N fertilization for the study area before giving a conclusive recommendation.**

Keywords – **Blended NPS Fertilizer, Inorganic N Fertilizer, Grain Yield, Maize.**

I. INTRODUCTION

Maize (*Zea mays* L) is one of the most important cereal crops in the world which is ranked second to wheat production [1]. It is second to tef (*Eragrostis tef)* in area coverage but first in productivity and total production among all cereals in Ethiopia [2]. Its economic importance being manifested by the different ways of consumption, going from human food and animal feed as well as bio-fuel to the high technology industry [3]. Nowadays, maize plays a key role in the food security and livelihoods of millions of poor farmers in the world-wide. Approximately 9.3 million smallholder farmers in Ethiopia grow maize, mainly for human consumption.

Maize is the most extensively cultivated food crops and main source of calorie in western, southern and eastern part of Ethiopian [4]. It is also an important source of income for these farmers [2]. The productivity of maize in Ethiopia in recent years has increased significantly due to several breeding programs as a response to pest and diseases such as the American rust. However, the average yield of maize in study area is very low; it is about 2.7 ton ha^{-1} Kachabirra District Agricultural Office (KDAO) [5]. As compared to the world's, national and regional average yield 4.2 ton ha^{-1}, 3.94 and 3.8 ton ha^{-1} respectively, [6].

The most limiting factors for sustainable maize production in smallholder farming systems of sub-Saharan Africa (SSA), especially the savanna agro-ecological zone, are unpredictable rains and low soil fertility. The major causes of the low soil fertility are low levels of nutrient inputs, continuous cropping, overgrazing, deforestation, and poor soil and water conservation measures [7]. Nitrogen and phosphorus are considered as the most deficient nutrients in soils of Ethiopia. This indicates that nitrogen and phosphorus are the most yield limiting factors of cereals including maize production in Ethiopia. Most of the fertilizer studies on maize have been conducted using NP fertilizers. To alleviate the soil fertility problem in the area, the office of agricultural and natural resources of the district has introduced chemical fertilizer blended with NPS fertilizer which contains nutrients N: P: S:: 19:38:7 and urea fertilizer in each District. However, the NPS fertilizer rate which is being used by farmers is blanket recommendation (100kg ha^{-1}) along with 46 kg N ha^{-1} through urea in the District. This fertilizer (blended NPS) which may or may not be sufficient to meet the crop requirement in the area. Thus, it is imperative to conduct location specific research on the response of one of the most popular varieties with the farmers to the newly introduced blended fertilizer in conjunction with nitrogen fertilizer that will help farmers to increase the yield of the crop. Therefore, the objectives of this study were to assess the effect of blended NPS fertilizer supplemented with inorganic N on yield and to determine the economically optimum levels of NPS and N required to obtain higher yield of maize.

II. Materials and Methods

2.1. *Description of the Study Area*

The experiment was conducted during 2019 main cropping season at Kachabirra District at Farmer Training Center (FTC), Southern Ethiopia. The site is located on geographic coordinates of 07°12'30"- 07°17'08" N latitude and 37°47'48"- 37°50'31"E longitudes and altitude of 1875 masl KDADO [8]. The rainfall in the area is characterized by bimodal distribution pattern and the main rainy season (*Meher)* is between June and end of September and short rainy season (*Belg*) is from late February to early April. The annual rainfall was 800mm to 1200mm rainfall. The average annual minimum and maximum air temperature of 15^0C and 28^0C, respectively KDAO [8].

2.2. *Soil Analysis Methods*

Soil samples were collected randomly from the entire experimental field following a zigzag fashion from 0 to 30 cm depth before planting using an augur. The collected soil samples were made one kg composite sample and used to determine soil chemical properties. The composite soil sample was air dried, crushed with wooden pestle and mortar to pass through a 2mm sieve size for the analysis of physical and chemical properties. Total nitrogen, available phosphorus, organic matter, soil pH, cation exchange capacity (CEC) and soil texture were determined in Sodo Soil Laboratory analysis using standard laboratory procedures. The soil pH was measured in 1:2.5 soil water ratios using an electrode pH meter. Organic carbon content of the soil was determined by Walkley and Black method [9], while available phosphorus was estimated following the standard procedure of [10] and total nitrogen was estimated by the Kjeldahl method [11].

2.3. *Experimental Materials*

Maize variety named BH661, which was used which developed and released by DTMA (Drought Tolerant Maize for Africa) project in Ethiopia in 2011 at Bako Agricultural Research Center [12]. It is a drought resistant hybrid variety; performing well in agro-ecological range of 1600-2200 m.a.s.l with rainfall range of 1000-1500 mm. It can give 95-120 q ha^{-1} and 65-85q ha^{-1} grain yields under research station and farmers field, respectively. Urea and blended NPS fertilizers were used as source of nutrients.

2.4. *Treatments, Experimental Design*

The treatments consist of four levels of NPS (0, 100, 150 and 200 kg ha^{-1}) each supplemented with five levels of nitrogen (0, 23, 46, 69 and 92 kg ha^{-1}). The experiment was laid in randomized complete block design (RCBD) with three replications.

Table 1. Details of fertilizer rates and their composition.

Treatments		
N	**P_2O_5**	**S**
0	0	0
23	0	0
46	0	0
69	0	0
92	0	0
19	38	7
41	38	7
65	38	7
88	38	7
111	38	7
28.5	57	10.5
51.5	57	10.5
74.5	57	10.5
97.5	57	10.5
120.5	57	10.5
38	76	14
61	76	14
84	76	14
107	76	14
130	76	14

2.5. *Management of the Experiment*

The experimental field was prepared following the conventional tillage practice which includes 3-4 times plowing before sowing of the crop. As per the specifications of the design, a field layout was prepared; the land was cleaned, leveled and made suitable for crop establishment. Gross plot size was 4.8m x 3.2m = (3.5*3) accommodating 4 rows each spaced 80cm. Spacing of 1.5m and 1m was maintained between adjacent blocks and plots, respectively. Sowing was done in April 2019 using seed rate of 25 kg ha^{-1}. Full dose NPS as per the treatment and one-third of N alone was applied at sowing time. The remaining N alone was applied in split, half at 35 and 65 days after planting in the form of urea. While conducting the experiment, other necessary agronomic management practices such as weeding, disease and insect pest control if any, were carried out uniformly for all treatments. The outermost one row from each side of a plot and 40 cm from each end of the rows was considered as border, thus the net plot size was 4 m x 2.4 m. The crop was harvested at physiological maturity and sun dried for about 10 days till constant weight before husking.

2.6. *Data Collection and Measurements*

Days to maturity was recorded as the number of days from date of sowing till in 90% of the plants change their green color to yellowish, lose its water content in net plot area.

Plant height was measured from the ground level to the top-most leaf of 6 randomly selected plants, from two central rows. A carpenter's tape was used for measuring the height from the ground level to the top-most leaf.

Number of kernel per cob was calculated by counting the number of kernel in five cobs of the two central rows of each subplot and then their average was calculated.

1000 grain weight was determined based on the weight of 1000 seeds sample from the cobs of the two central rows of each sub plot and weighing with an electronic balance and the yield was adjusted to 12.5% moisture level.

The grain yield was taken by husking and cleaning the grain yield from net plot area and converted to in kg ha^{-1} or ton ha^{-1}. The yield was adjusted to 12.5% moisture. **Harvest index** was calculated as the ratio of grain yield to the aboveground dry biomass yield expressed as a percentage.

$$\text{HI}(\%) = \frac{\textit{Grain yield/plot}}{\textit{Above ground dry biomass/plot}} \times 100$$

2.7. *Data Analysis*

The data was subjected to analysis of variance (ANOVA) as per the experimental designs for each experiment using GenStat (15th edition) software [13]. The Least Significance Difference (LSD) at 5% level of probability procedure was used to determine differences between treatment means.

2.8. *Partial Budget Analysis*

As farmers attempt to evaluate the economic benefits of shift in practice, partial budget analysis was done to identify the economic feasibility of the treatments. Yield from on-farm experimental plots were adjusted downward by 10% *i.e.*, for management and for plot size difference, to reflect the difference between the experi-

-mental yield and the yield that farmers could expect from the same treatment.

III. Results and Discussion

3.1. *Soil Physicochemical Properties before Planting*

The pH of the experimental site was 5.84, which as rated by [18] is slightly acidic. This value falls in the pH range that is very conducive for maize production as normal soil pH for maize is recorded to be from 5-8, with a pH of 6-7 probably being an optimal for most varieties [3]. The organic carbon content of 0.64% in the soil of the study site could be rated as very low according to the rating of [18] and the total nitrogen content was low according to [14]. The CEC of the soil was medium, according to [15]. According to the rating of [16], the available P is very low (Table 2).

Table 2. Soil physicochemical properties of the experimental sites before planting.

Physical properties	**Content**	**Rating**	**Sources**
Soil texture:			
Sand (%)	63	High	[15]
Silt (%)	28	Moderate	[15]
Clay (%)	35	Low	[15]
Textural class		Loam	[17]
Chemical properties			
pH (1:2.5 H_2O)	5.84	SA	[18]
Organic carbon (%)	0.64	Very low	[18]
Total N (%)	0.182	Low	[14]
Available P (mg/kg)	5.3	low	[16]
CEC Cmol+/kg of soil	22.56	Medium	[15]

CEC = Cation exchange capacity, SA = slightly acidic.

3.2. *Crop Phenology and Growth Parameters*

3.2.1. *Days to maturity*

The result indicated that the main effects of SN and NPS as well as interaction had a highly significant ($P<0.01$) effect on days to physiological maturity of maize (Table 3). The highest number of days to physiological maturity (99.00 days) was observed due to 200 kg NPS fertilizer ha^{-1} supplemented with 92 kg SN ha^{-1}, whereas the lowest (140.7 days) were observed from control treatment (Table 3). The applied SN delayed days to 90% physiological maturity with increased rate of NPS fertilizer. Similar trend was observed due to applied SN and NPS. The delay in maturity of maize plants in response to the increasingly NPS and SN applications might be because of the fact that increased rate of nitrogen, which delays physiological maturity by promoting vigorous vegetative growth and development of the plants. This result is supported by [19] who reported that increased physiological maturity with increasing levels of nitrogen in open pollinated varieties of maize. The result is also in conformity with the established fact that abundant supply of nitrogen delays physiological maturity by promoting vigorous vegetative growth of the plant [20].

Table 3. Days to 90% physiological maturity of maize as influenced by the interaction of NPS and supplemental nitrogen (SN).

Supplemental Nitrogen ($kg\ ha^{-1}$)	**Blended NPS ($kg\ ha^{-1}$)**			
	0	**100**	**150**	**200**
0	151.3^{i}	155.0^{h}	156.0^{gh}	159.0^{f}
23	156.0^{gh}	155.7^{h}	163.3^{de}	162.3^{e}
46	155.7^{h}	157.0^{fgh}	164.7^{cde}	165.0^{bcd}
69	158.3^{fg}	163.0^{de}	165.0^{bcd}	167.3^{ab}
92	162.7^{de}	163.0^{de}	167.0^{abc}	169.3^{a}
LSD(0.05)	1.381			
CV (%)	0.5			

Parameter means followed by the same letter within columns are not significantly different at 5% level of significance according to Tukey Tests; CV = Coefficient of variance; LSD = Least Significant Difference at 5% level.

3.2.2. *Plant Height*

The analysis of variance showed statistically significant ($P<0.01$) difference in plant height due to main effects of NPS, supplemental nitrogen and the interaction effect (Table 4). Significantly tallest (3.660 m) and shortest (2.443 m) plants were recorded due to 200 kg blended NPS supplemented with 92 kg SN ha^{-1} (130 N:76 P:14 S) and 100 kg NPS supplemented with 0 kg SN ha^{-1}, respectively (Table 4). Thus, the mean height of plants grown at the rates of 200 kg blended NPS ha^{-1} supplemented with 92 kg SN ha^{-1} was significantly taller than to the mean height of plants grown at 100 kg blended NPS ha^{-1} with 0 kg SN ha^{-1} by 49.82 % (Table 4). The increased plant height at the highest level of blended NPS fertilizer supplemented with supplemental nitrogen rates could be attributed to the increasingly adequate supply of nitrogen, phosphorus and sulphur nutrients, which attributed to better vegetative development that resulted in increased mutual shading and internodal extension. Similarly, [20] reported that plant height of maize increased with increased level of N and P. The result of this study also in line with the findings of [22] who reported that the beneficial role of N and P in cell division and elongation as well as the root growth and dry matter content of plants.

Table 4. Plant height (m) of maize as influenced by the interaction effect of blended NPS and supplemental nitrogen (SN).

Supplemental Nitrogen ($kg\ ha^{-1}$)	**Blended NPS ($kg\ ha^{-1}$)**			
	0	**100**	**150**	**200**
0	2.120^{j}	2.443^{hi}	2.487^{ghi}	2.710^{f}
23	2.387^{i}	2.620^{fgh}	3.140^{de}	3.287^{cd}
46	2.407^{i}	3.207^{de}	3.100^{e}	3.400^{bc}
69	2.510^{ghi}	2.627^{fg}	3.260^{cde}	3.487^{ab}
92	2.627^{fg}	3.200^{de}	3.400^{bc}	3.660^{a}

Supplemental Nitrogen (kg ha^{-1})	Blended NPS (kg ha^{-1})			
	0	100	150	200
	LSD(0.05)	0.09693		
	CV (%)	2.0		

Parameter means followed by the same letter within columns are not significantly different at 5% level of significance according to Tukey Tests; CV = Coefficient of variance; LSD = Least Significant Difference at 5% level.

3.3. *Yield and Yield Components*

3.3.1. *Number of Kernel Per Cob (NKPC)*

Number of kernels per cob was highly significantly (P<0.01) affected by the main effects of NPS fertilizer application and SN fertilizer rate as well as by the interaction (Table 5). The comparison of the mean values of the number of kernel per cob showed that the maximum number of kernels per cob (614.0) was recorded due to 200 kg NPS with 69 kg SN ha^{-1}, whereas the minimum among (420.3) and the whole treatment (383.0) were due to 100 kg NPS fertilizer ha^{-1} supplemented with 0 kg SN ha^{-1} and control treatment, respectively (Table 8). Indicating positive effect of applied NPS and SN of NKPC. It could be concluded that N encouraged growth in maize plants as a result of its vital role on photosynthetic activity in maize plants. The results were similar with that of [23, 24] who reported that number of kernel per cob were influenced significantly with NP application.

Table 5. Mean number of kernels per cob of maize as influenced by the interaction effect of blended NPS rate and supplemental nitrogen (SN).

Supplemental Nitrogen (kg ha^{-1})	Blended NPS (kg ha^{-1})			
	0	100	150	200
0	383.0^{g}	420.3^{fg}	438.7^{ef}	479.3^{de}
23	419.0^{fg}	444.7^{ef}	456.3^{ef}	540.3^{bc}
46	428.0^{efg}	454.0^{ef}	475.3^{de}	570.0^{abc}
69	435.3^{efg}	457.7^{ef}	522.7^{cd}	614.0^{a}
92	438.3^{ef}	476.3^{de}	555.3^{bc}	576.3^{ab}
	LSD(0.05)	27.87		
	CV (%)	3.5		

Parameter means followed by the same letter within columns are not significantly different at 5% level of significance according to Tukey Tests; CV = Coefficient of variance; LSD = Least Significant Difference at 5% level.

3.3.2. 1000 *Grain Weight*

1000 kernels weight (TKW) was significantly influenced by the main effect of blended NPS, SN as well as by the interaction of NPS × *N* rate (Table 6). The application of 200 kg NPS ha^{-1} supplemented with 92 kg SN ha^{-1} produced the highest (441.7g) thousand kernels weight, whereas the lowest (319.4 g) thousand kernels weight value was recorded when 100 kg blended NPS ha^{-1} supplemented with 0 kg SN ha^{-1} (Table 6). The increment in TKW in response to increased rates of the SN fertilizer may be attributed to the availability of optimum N that led to high mean TKW through facilitating leaf growth and photosynthetic activities. The result obtained from this study is in line with the findings of [25] who reported a significant effect of N treatment on TKW of maize.

Table 6. Mean thousand-kernel weight (g) of maize as influenced by the interaction effect of blended NPS rate and supplemental nitrogen (SN).

Supplemental Nitrogen (kg ha^{-1})	Blended NPS (kg ha^{-1})			
	0	100	150	200
0	283.0^{h}	319.4^{fgh}	320.0^{fgh}	320.9^{fgh}
23	304.3^{gh}	329.6^{efgh}	323.8^{efgh}	332.4^{efg}
46	320.3^{fgh}	352.7^{cdefg}	372.1^{cde}	364.7^{cdef}
69	327.1^{efgh}	385.4^{bcd}	400.7^{abc}	441.7^{a}
92	337.0^{defg}	339.3^{defg}	400.0^{abc}	429.0^{ab}
LSD(0.05)		25.92		
CV (%)		4.5		

Parameter means followed by the same letter within columns are not significantly different at 5% level of significance according to Tukey Tests; CV = Coefficient of variance; LSD = Least Significant Difference at 5% level.

3.3.3. *The Grain Yield*

The means of maize grain yield was highly significantly ($P<0.01$) affected by the main effects of blended NPS fertilizer application and SN fertilizer rate as well as their interactions (Table 7). The highest grain yield (8680 kg ha^{-1}) was obtained in response to the application of 200 kg NPS ha^{-1} with 92 kg SN ha^{-1}, which was statistically similar to that were observed due to 200 kg blended NPS ha^{-1} supplemented with 69 kg SN ha^{-1} and 46 kg SN ha$^{-1,}$ whereas the lowest (2097 kg ha^{-1}) grain yield was obtained from control treatment (Table 7). Generally, at the rate of SN there is yield increase as the rate of NPS increased might be because of the fact that phosphate application as being particularly useful in promoting good root system, which could favor the best utilization of mineral nutrients from the soil [3]. The result obtained from this study is in line with the research findings of many other researchers [21, 26] all of whom observed significant increases in grain yields of maize with increasing application levels of N fertilizer. Similarly, [27] found that different rates of P application had a significant effect on maize grain yield. The result also agreed with the findings of [28] who reported that combined application of N with S fertilizers increases the net photosynthetic rate in crop plants, which in turn increases their grain yield of the plants.

Table 7. Mean grain yield (kg ha^{-1}) of maize as influenced by the interaction effect of NPS rate and supplemental nitrogen (SN**).**

Supplemental Nitrogen (kg ha^{-1})	Blended NPS (kg ha^{-1})			
	0	100	150	200
0	2097^{h}	4850^{defg}	5300^{def}	4225^{efg}
23	3371^{gh}	5373de	4237^{efg}	5633^{cde}
46	3453^{fgh}	5603^{cde}	6334^{bcd}	6283^{bcd}

Supplemental Nitrogen (kg ha^{-1})	Blended NPS (kg ha^{-1})			
	0	100	150	200
69	5606^{cde}	4885^{defg}	7260^{bcd}	7828^{ab}
92	4856^{defg}	6297^{bcd}	6282^{bcd}	8680^{a}
LSD(0.05)	1001.6			
CV (%)	11.2			

Parameter means followed by the same letter within columns are not significantly different at 5% level of significance according to Tukey Tests; CV = Coefficient of variance; LSD = Least Significant Difference at 5% level.

3.3.4. *Aboveground Dry Biomass (AGB)*

The analysis of variance indicated that the main effects of blended NPS and SN application had highly significant effect on AGB of maize. Likewise, the interaction of NPS × N application N also revealed a significant effect on AGB. The maximum AGB (19748 kg ha^{-1}) was obtained at the combined application of 200 N kg ha^{-1} with 92 kg SN ha^{-1}, whereas the minimum AGB among the blended NPS (13011 kg ha^{-1}) and the whole treatment (7862 kg ha^{-1}) were due to 150 kg blended NPS fertilizer ha^{-1} supplemented with 23 kg SN ha$^{-1,}$ and control treatment, respectively (Table 8). The possible reason for this response could be due to adequate supply of N and P application and their assimilation in meristematic tissue which might have played an important role in tillering and overall plant growth. The result is consistent with that of [29] who found that combined application of nitrogen and phosphorus increased AGB of maize revealing the benefit realized by exploiting interactions. Similar to this result [30] reported the combination of nitrogen and phosphorus leads to an increase in dry matter accumulation.

Table 8. Interaction effect of NPS with SN fertilizers on above ground dry biomass of maize.

Supplemental Nitrogen (kg ha^{-1})	Blended NPS (kg ha^{-1})			
	0	100	150	200
0	7862^{k}	15373^{defg}	15681^{cdefg}	13595^{ghi}
23	11030^{j}	17320^{bcde}	13011^{hij}	17031^{bcde}
46	11850^{ij}	16768^{bcdef}	17328^{bcde}	17341^{bcde}
69	13478^{ghi}	15222^{efgh}	18252^{ab}	18203^{ab}
92	14534^{fgh}	17535^{abcd}	17660^{abc}	19748^{a}
LSD(0.05)	1197.5			
CV (%)	4.7			

Parameter means followed by the same letter within columns are not significantly different at 5% level of significance according to Tukey Tests; CV = Coefficient of variance; LSD = Least Significant Difference at 5% level.

3.3.5. *Harvest Index*

Harvest index (HI) was highly significantly influenced by the application of blended NPS and SN and their i-

-nteraction (Table 9). A generally significant effect of two-way interactions was also observed. With regard to the interaction effect of blended NPS × N rate, the highest value of HI (43.96%) was obtained due to 200 kg blended NPS ha^{-1} supplemented with 92 kg SN ha^{-1}, whereas the lowest(31.04%) among the blended NPS and (26.66%) HI was obtained due to 100 kg blended NPS ha^{-1} supplemented with 23 kg SN ha^{-1} and control treatments, respectively (Table 9). The increment in HI at higher rates of blended NPS combined with SN might be attributed to greater photo assimilate production and its ultimate partitioning into grain yield. This result is supported by [31, 33] reported that the harvest index in corn increases when N rates increase. The result of this study also agrees with the finding of [32] who reported a significant increase of the harvest index of sorghum with increased levels of added P.

Table 9. Harvest index (%) of maize as influenced by the interaction of NPS rate and SN.

Supplemental nitrogen ($kg\ ha^{-1}$)2	**Blended NPS ($kg\ ha^{-1}$)**			
	0	**100**	**150**	**200**
0	26.66^{f}	31.60^{def}	33.80^{bcdef}	31.09^{def}
23	30.58^{def}	31.04^{def}	32.56^{cdef}	33.10^{cdef}
46	29.16^{ef}	33.41^{cdef}	36.56^{abcde}	36.23^{abcdef}
69	41.60^{abc}	32.11^{cdef}	39.55^{abcd}	43.07^{ab}
92	33.41^{cdef}	35.91^{abcdf}	35.26^{abcdef}	43.96^{a}
LSD(0.05)	5.104			
CV (%)	8.9			

Parameter means followed by the same letter within columns are not significantly different at 5% level of significance according to Tukey Tests; CV = Coefficient of variance; LSD = Least Significant Difference at 5% level.

3.4. *Partial Budget Analysis*

The results of partial budget analysis showed that the maximum net benefit (Birr 88346 ha^{-1}) with an acceptable marginal rate of return(MRR) was obtained from 200 kg blended NPS ha^{-1} fertilizer supplemented with 92 kg SN ha^{-1} application, whereas the lowest net benefit among the fertilized treatments was obtained from the 100 kg blended NPS ha^{-1} with 0 kg SN ha^{-1} (Birr 36461 ha^{-1}),but the net benefit of control treatment (Birr 22647.6 ha^{-1}) was the least (Table 10). This has resulted in a net benefit advantage of Birr 44280 and 65698.4 ha^{-1} over the 100 kg blended NPS with 0 kg SN ha^{-1} and control rate, respectively of NPS fertilizer with SN application (Table 10). The application of 200 kg NPS ha^{-1} + 92 kg SN ha^{-1} resulted in above the maximum acceptable rate of return, *i.e*. 1349.07% marginal rate of return. This implies that for each ETB investment in maize production, the producer can get additional ETB 13.48 for treatment with 200 kg NPS ha^{-1} + 92 kg SN ha^{-1}.

In conclusion, the net benefit obtained by the use of hybrid maize with rates of 200 kg NPS ha^{-1}+ 92 kg SN ha^{-1} was found to be greater than the benefit of applying blended NPS and SN at the blanket recommendation rates (100 kg NPS ha^{-1} + 100 kg SN ha^{-1}). Therefore, the net positive benefit obtained with application of 200 kg blended NPS ha^{-1} + 92 kg SN ha^{-1} to maize are economically profitable application rates and can be recommended for farmers in study area and other areas with similar agro-ecological conditions.

Table 10. Marginal analysis of maize yield as influenced by blended NPS fertilizer supplemented with nitrogen rate.

NPS (kg ha^{-1})	SN (kg ha^{-1})	Average Yield (kg ha^{-1})	Adjusted Yield (kg ha^{-1})	GB (Birr ha^{-1})	TVC (Birr ha^{-1})	NB (Birr ha^{-1})	MRR (%)
0	0	2097	1887.3	22647.6	0	22647.6	0
0	50	3371	3033.9	36406.8	905	35501.8	1420.35
0	100	3453	3107.7	37292.4	1540	35752.4	39.46
100	0	4949	3802.5	45630	1564	44066	34640
150	50	4225	3813.3	45759.6	2846	42913.6	D
100	0	4237	4365	52380	1564	50816	D
0	200	4850	4370.4	52444.8	2810	49634.8	D
100	150	4856	4396.5	52758	3469	49289	D
150	0	4885	4770	57240	2211	55029	D
100	50	5300	4835.7	58028.4	2199	55829.4	D
100	100	5373	5042.7	60512.4	2834	57678.4	291.12
0	150	5603	5045.4	60544.8	2175	58369.8	D
200	50	5606	5069.7	60836.4	3493	57343.4	D
150	200	5633	5653.8	67845.6	4751	63094.6	457.17
200	100	6282	5654.7	67856.4	4128	63728.4	D
100	200	6297	5667.3	68007.6	4104	63903.6	D
150	100	6334	5700.6	68407.2	3481	64926.2	D
150	150	7260	6534	78408	4116	74292	1474.93
200	150	7828	7045.2	84542.4	4763	79779.4	848.13
200	200	8680	7812	93744	5398	88346	1349.07

SN = Supplemental nitrogen; ETB = Ethiopian Birr; GB = Gross benefit; TVC = Total variable cost; NB = Net benefit; D = Dominated treatment's, MRR = Marginal rate of return.

IV. Conclusions

The results of the soil tests revealed that most of the chemical properties of the experimental site were indicative of low fertility status. Thus, chemical properties of the soil such as organic carbon content, pH, CEC, total nitrogen, and available phosphorus were found to be low. The results of the field experiment revealed all parameters were significantly affected by the main effect of blended NPS and SN, except number of kernel rows per cop. Similarly, the interaction effects of blended NPS and supplemental nitrogen also brought highly significant effect on all parameters, except days to 50% silking and number of kernel row per cob. The highest grain yield (8680 kg ha^{-1}) was obtained due to 200 kg blended NPS ha^{-1} supplemented with 92 kg SN ha^{-1}, but maximum yield was obtained at 200 kg blended NPS ha^{-1} supplemented with 92 kg SN ha^{-1} did not show statistically significant differences were observed due to 200 kg blended NPS ha^{-1} supplemented with 69 kg SN ha^{-1} and 46 kg SN ha^{-1}, whereas the lowest (2097 kg ha^{-1}) grain yield was obtained from control treatment. Then it could be concluded that, the results of this study have indicated that the use of higher blended NPS fertilizer with supplemental N rates are the realistic approach to address the problem of low productivity of maize in the study area. In general, the combination rate of 200 kg blended NPS ha^{-1} and 92 kg SN ha^{-1} produced maximum grain yields, together with the best economic benefit. Therefore, this treatment could be recommended for the farmers in the study area instead of using 100 kg NPS with 46 kg SN ha^{-1}. So further studies is needed to recommend agronomical optimum and economically feasible levels of NPS and N fertilization for the study area before giving a conclusive recommendation.

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