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Phenology, Growth, Yield, Nutrient use Efficiency and Economic Feasibility Response of Bread Wheat (*Triticum aestivem* L.*)* to NPSB and N Fertilize Rates Under Limed Condition in Gechi District, Southwestern Ethiopia

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***Abstract* – Wheat (*Triticum aestivum L.*) is one of the most important cereal crops in Ethiopia but its yield was lower primarily due to low soil fertility and use of inappropriate fertilizer rates. This study was conducted to determine the effect of NPSB and N fertilizer rates on yield and yield components of wheat under limed condition during 2019/2020 cropping season. The experiment consisted four levels of NPSB (0,50,100 and 150 kg / ha) and four levels of N (0,23,46 and 69 kg/ha) fertilizers. The experiment was laid out in 4X4 factorial arrangement in randomized complete block design with three replications. The results of the experiment indicated that days to heading, maturity days, plant height and spike length were significantly affected by only the main effects of NPSB and N. The longest day to heading (64.6 days), days to maturity (122.2 days), plant height (81.6 cm) and spike length (6.92cm) were recorded at the highest rate of N fertilizer (69 kg/ha). The maximum number of total tillers (6 par plant), productive tillers (4.14 plant), number of Spikeles per plant (23.12), grain yield (6.4 ton /ha), biomass yield (10.73 ton/ha), straw yield (4.4 ton/ha), harvest index (59.2%), and number of seed per spike (52.00 seed) were obtained at combining application of 150 kg/ha NPSB with 69 kg/ha of N. effects of NPSB and N. However,the higher value of Agronomic efficiency, physiological efficiency and nutrient recovery of nitrogen was obtained at lowest Nitrogen rate.The result of economic analysis showed that combined application of 150 kg /ha NPSB and 46 N kg/ha of N gave economic benefit of 100328.24 Birr/ha with the marginal rate of return of 3321.93%. Thus, the use of 150 kg/ha of NPSB and 46 kg/ha of N can be recommended for better production of bread wheat in the study area.**

***Keywords* – Blended Fertilizer, Liban, Soil Test Based Fertilizer Recommendation.**

I. Introduction

Wheat (*Triticum aestivum* L.) is a staple food that provides around 20% of protein and calories consumed world wide [1]. Ethiopia is one of the largest producers of wheat in sub-Saharan Africa. Though Ethiopian agro-climatic condition is suitable for wheat production, productivity of the crop is low. Accordingly, the national average productivity of wheat was estimated at 2.4 tons/ha, which is by far below the world's average (3.27 tons /ha) [2]. This is because of soil fertility depletion, Soil acidity, low levels of chemical fertilizer usage, limited knowledge on time and rate of fertilizer application, and the unavailability of other improved crop management practices [3].

In the past four to five decades, fertilizer consumption in the country has been limited to Urea and DAP as N and P sources. Thus, Ethiopia is moving from applications of blanket fertilizer recommendations to recommendations that are customized based on soil nutrient analysis, soil type and crop nutrient requirments [4].

Blended fertilizers, such as NPSB (18.9% N, 37.7% P_2O5, 6.95% S, and 0.1% B) are currently being used by

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the farmers in the study area based on the recommendation drawn from soil fertility map of the areas [5]. Nevertheless, the N content per 100 kg of the blended fertilizer (NPSB) is 18 kg, which is far lower than the blanket nitrogen recommendation (100 kg/ha of Urea) [6]. This condition necessitated application of additional amount of N in the form of Urea.

However, farmers in most areas of the country, particularly in Gechi district, have limited information on the use of balanced fertilizer types and rates, except for urea and di-ammonium phosphate (DAP) as which are source of N and P. Furthermore, the rate and response of blended NPSB and N fertilizers for wheat production has not been determined in most cases. Therefore, the present study was undertaken to determine the effect of NPSB and N fertilizerrates on the yield and yield components of wheat under limed condition in Gechi District.

II. Material and Methods

A field experiment was conducted during the 2019/2020 main cropping season under rain-fed condition in Gechi District, Buno Bedele Zone of Oromia Regional State. The experimental site was located at 08^{0}18’19.0”N latitude and 036^{0}26’25.0’’E longitude at an altitude of 2133 masl (Meter above sea level). Fifteen years (2005-2019) climatic data shows that the area receives a unimodal type of rainfall pattern, main rain occurring between May to september with mean total annual rainfall of 1970 mm. According to Bedele meteorological data, the total annual rainfall in the 2019 season was 2199 mm. The mean annual minimum and maximum temperatures of the area are 13˚C and 26˚C, respectively. The soil in the study area is predominantly Nitisol with deficient in nitrogen (N), phosphorous (P), sulfur (S), boron(B),and copper (Cu) [6].

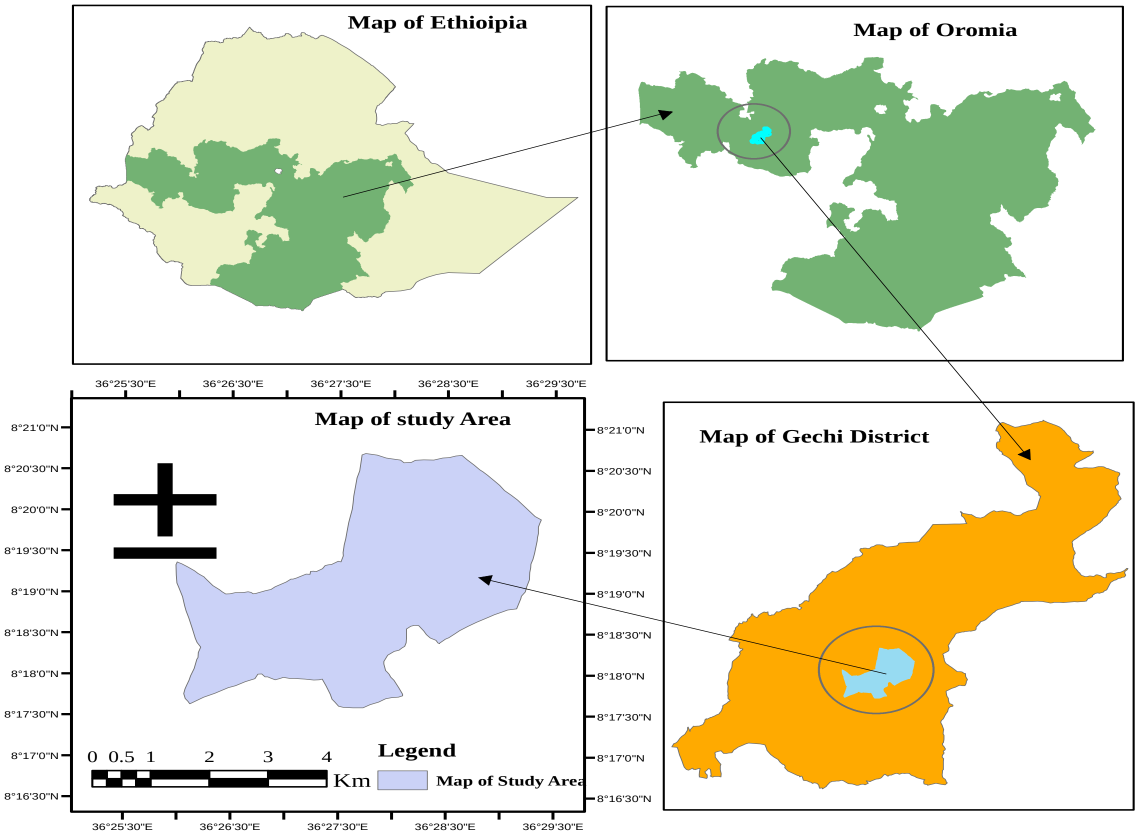

Fig. 1. Map of the study area.

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2.1. *Treatments, Experimental Design and Procedure*

The treatment consisted of each four levels of NPSB (0, 50, 100, and 150 kg/ha) and N (0, 23, 46, and 69 kg/ha) fertilizers. A total of 16 treatment combinations were considered. The experiment was laid out in a randomized complete block design (RCBD) in a factorial arrangement replicated three times. The total number of plots in the experiment were 48 (16 × 3), each with 3 m × 2 m (6 m^2) size. The distances between plots and blocks were 0.5 m and 1.0 m, respectively. Each plot consisted of 15 rows spaced 20 cm apart. The net plot areas of each plot consisting of 13 rows of 4.16 m^2 were harvested and used for yield determination. The one outer most rows were kept as borde effect from each side of all plots. Urea (46% N) and blended NPSB (18.9% N, 37.7 P2O5 %, 6.95 S %, 0.1% B) were used as fertilizer sources. NPSB were applied at planting time close to seed drilling line, while N in form of urea fertilizer was applied in split application, the entire N in form of urea fertilizer at planting time and the remaining urea fertilizer was top dressed at 40 days after planting and second weeding in the form of urea. Bread wheat varieties Liban was drilled at the rate of 150 kg/ha (90 gm/ plot) in rows 20 cm apart. Weeds were removed by hand when required. Rouging of lately emerging grasses and off-type plants were done to avoid interference with the wheat. All other recommended cultural practices for the test crop were done as per the recommendation to the area.

2.2. *Soil Sampling and Lime Requirement Determination*

One composite soil sample made from 21 sub samples, were collected from the depth of 0 to 20 cm using auger before planting. The samples were well mixed manually and air dried, then ground using a pestle and a mortar and allowed to pass through a 2 mm sieve. The samples were analyzed for selected physico-chemical properties mainly organic carbon, total N, soil pH, available phosphorus (P), available sulfur, available boron, cation exchange capacity and soil texture using the procedure at Bedele agricultural research center. Lime Requirement (LR) of site and crop was determined based on exchangeable acidity (Ex. Ac). LR (t/ ha) = Exchangeable Acidity*1.5*10 [7]. Where; LR=Lime requirement.

2.3. *Data Collection*

2.3.1. *Agronomic Data*

Data on crop phonology and growth parameters (Days to heading, Days to Physiological maturity, productive tillers, Spike length, plant height and leaf number), and yield and yield components (number of kernels per spick, Thousand Kernel weight, Grain yield, The above ground dry biomass, Straw yield and Harvest Index) were collected and analyzed.

2.3.2. *Agronomic Efficiency of Nitrogen*

The nitrogen use efficiencies of wheat such as agronomic efficiency, physiological efficiency and apparent recovery efficiency of N were calculated as describe by Fageria and Baligar (2001).

$$AE = \frac{Yf - Yo}{f} \quad (1)$$

Where, AE Agronomic Efficiency, Yf is the grain yield of a fertilized plot (kg/ha), Y0 is the grain yield of the control plot (kg/ha), and f is the amount of N applied (kg/ha).

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$$PE = \frac{Yf - Yu}{Nf - Nu} \quad (2)$$

Where, PE is Physiological Efficiency,Yf is the biological yield (grain plus straw) of the fertilized pot (kg/ha); Yu is the biological yield of the unfertilized plot (kg/ha); Nf is the nutrient uptake (grain plus straw) of the fertilized plot; and Nu is the nutrient uptake (grain plus straw) of the unfertilized plot (kg/ha).

$$ARE = \frac{Uf - Uo}{f} * 100 \quad (3)$$

Where, ARE is Apparent Recovery Efficiency, UF is nutrient (N) uptake in above ground biomass of fertilized plots (kg/ha). U0 is nutrient (N) uptake in above ground biomass of the control plot (kg/ha), and F is the amount of N applied (kg/ha).

2.4. *Statistical Analysis*

All the measured parameters were subjected were first checked for all assumptions of ANOVA. Then the data were subjected to Analysis of Variance (ANOVA) using SAS CORR [8] by SAS version 9.3). The data collected were statistically analyzed using the Analysis of Variance (ANOVA) procedures. Means were separated using the LSD test to signify the treatment differences at a 5% level of probability.

2.5. *Partial Budget Analysis*

Economic analysis was conducted based on the procedure provided by CIMMYT (9). Total variable cost was calculated as the sum of all cost that is variable or specific to specific treatment against the control. Net benefit was calculated by subtracting total variable cost from the gross benefit. Marginal rate of return (MRR) was calculated as the ratio of differences between net benefits of successive treatments to the difference between total variable costs of successive treatments. When the net benefit from preceding treatments found to be higher than net benefit from subsequent treatment, it is considered as dominated (D). MRR (%) = (NB*100)/ TVC.Where: NB = Net benefit, TVC = Total variable cost and MRR = marginal rate of return.

III. Results and Discussion

3.1. *Selected Soil Physical and Chemical Properties of the Site Before sowing*

The analysis results indicated that the proportions of soil particle size distribution were 27, 25 and 48 % sand, silt and clay respectively with a clay textural class (Table 2).

Table 1. Selected physical and chemical properties of soil before sowing of bread wheat in 2019 at Gito Kebele in Gechi district.

Soil Properties	Value	Rating	Reference
Textural class	Clay	-	
Clay (%)	48	Very High	
Silt (%)	27	Low	
Sand (%)	25	Low	
Bulk density(gm/cm^3)	1.101	Good for Production	[10]
pH (1: 2.5 H2O)	4.48	Very Acidic	[10]

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Soil Properties	Value	Rating	Reference
CEC [Cmol(+)kg-1 soil]	15.791	Medium	[10]
Organic Carbon (%)	4.813	High	[10]
organic Matter (%)	8.29	High	[11]
Total N (%)	0.192	Medium	[11]
Available phosphorus(mg/kg)	0.621	Very low	[12]
Available sulfur (mg/kg)	16.08	Low	[13]
Available boron (mg/kg)	0.346	Low	[14]

3.2. *Effect of NPSB and N on Wheat Phenology and Growth Parameters*

3.2.1. *Days to 50% Heading*

The main effect of NPSB and N fertilizer rates were highly significant (P<0.01) on the number Days to 50% heading whereas interaction of NPSB and N were showed none significant (P>0.05) effect on Days to 50% heading (Table 2). The highest days to heading (64.58 days) was recorded by applying 69 kg/ha of N while the earliest days to heading (58.5 days) was recorded in the control (unfertilized) plot (Table 2). Regarding to NPSB fertilizer rates, increasing application of NPSB fertilizer rates results in prolonged days to heading. Accordigly, the longest days to heading (62.92) recorded by application of 150 Kg/ha NPSB. While, the shortest (60.00) was under under control plot which is statistically the same with application 50 kg/ha of NPSB (Table 3). It might be due to the availability of high balanced nutrient at active growing stages of the plant which result in excessive vegetative growth that delays heading. Abebaw and Hirpa [14] stated that that application of blend fertilizer like NPSB prolongs vegetative growth stage of wheat, but the control treatment 0 kg fertilizer showed shortest days which could be nutrient deficiency fastens to develop spike for bread wheat.

3.2.2. *Days to 90% Physiological Maturity*

Days to physiological maturity were highly significantly (P<0.001) influenced by the main effect of NPSB and N fertilizer. However the interaction of NPSB and N showed none significantly (P>0.05) influenced 90% physiological maturity (Table 2). Similar to number of days to heading, application of high rate of NPSB and N delayed days to physiological maturity of bread wheat (Table 2). This may be attributed to the physiological effect of the fertilizer NPSB and N which increases vegetative growth of crops whereby it delays maturity time. The fact that N is important for synthesis of major macro-molecules in plants including proteins, enzymes, pigments and growth promoting hormones. The result of the present study is supported by finding of Wogene Solomon and Agena Anjulo [15] who reported that days for maturity of bread wheat was prolonged as nitrogen fertilizer level applied increased.

3.2.3. *Plant Height*

The main effect of NPSB and N fertilizer rates highly significantly affected the plant height at (p<0.01). But interaction effect NPSB and N were showed none significant (P>0.05) influence plant height (Table 2). Thus,the tallest plant (81.50 cm) was obtained at the highest rate of 69 kg/ha where as shortest plant height (75.5cm) was

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recorded in control treatment (Table 2). Regarding to NPSB fertilizer rates, the increased plant height in response to increasing rate of NPSB fertilizer was due to the effect of N on the blended fertilizer, which has the vital role of N fertilizer in promoting the vegetative growth, and resulted in significant increase in plant height.

3.2.4. *Spike Length*

The main effects of blended NPSB and N fertilizer rates were significant (P<0.01) in influencing the spike length of bread wheat. However, the interaction not showed significantly (P >0.05) interacted to influence spike length (Table 2). The shortest spike length (5.25 cm) was recorded in the control (unfertilized) treatment whereas, the longest mean spike length (6.69cm) was recorded at application of 150 kg/ha NPSB and 69 kg/ha of N (Table 2). The spike length increment with the blended fertilizer application might be attributed due to better photo assimilate supply [16]. He also suggested that the higher the length of spike the higher would be grain produced/spike leading to higher yield. Moreover, this due to the fact that N is essential for increased cell division and elongation, which is resulting in improvement of vegetative growth.

Table 2. Main effect of NPSB and N fertilizers on days to heading, maturity date, plant height and spike length of bread wheat in 2019 at Gechi ditrict, Ethiopia.

Treatment	Heading Date	Maturity Date	Plant Height	Spike Length
NPSB				
0	60.00^{b}	113.00^{b}	77.00^{b}	5.25^{c}
50	61.25^{b}	115.50^{b}	78.25^{b}	5.46^{c}
100	63.750 ^{a}	120.50 ^{a}	80.75 ^{a}	5.96^{b}
150	62.92^{a}	118.83^{a}	79.92b^{a}	6.33^{a}
LSD(0.05)	2.23	4.58	2.19	0.41
N (Kg/ha)				
0	58.50^{c}	110.00^{c}	75.50^{c}	5.4583^{b}
23	61.25^{b}	115.50^{b}	78.25^{b}	5.7083^{b}
46	63.58^{a}	120.17^{a}	80.58^{a}	6.08^{a}
69	64.58^{a}	122.17^{a}	81.58^{a}	6.69^{a}
LSD(0.05)	2.41	4.49	2.24	0.33
CV	4.32	4.47	2.68	6.66

Means in the table followed by the same letter (s) are not significantly different at 5% level of significance.

3.3. *Effects of NPSB and N on Yield and Yield Components of Bread wheat*

3.3.1. *Total Number of Tillers*

The main effects of NPSB and N fertilizer rates were highly significant (< 0.01) for total number of tillers per plant. Similarly, the interaction of the two factors was also significant (P<0.05) (Table 3). The highest total number of tillers per plant (6) was produced by plants treated with the highest rate of combined application of (150 kg/ ha) NPSB and (69 kg/ha) N whereas the lowest value (1/ plants) was recorded for the unfertilized plot (Table 3).

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In general, combined application of 150 kg/ha of NPSB and 69 kg/ha of N resulted in more than six (6) times incrementin total number of tillers over the control plot. The improvement in total number of tillers at the highest rates of combined application of blended NPSB and N might be attributed to the synergetic roles of the four nutrients in enhancing growth and development of the crop.

The increase in the number of tillers in response to increasing rate of blended NPSB fertilizer indicated the importance of availability of balanced nutrients for better growth and development of wheat. The more availability of N at the highest rates of NPSB might have played a positive role in cytokinin synthesis and cell division and, there by, accelerated the vegetative growth of plants. Furthermore, total tiller was positive correlation with yield and selected yield component.

Table 3. Effect of NPSB and N fertilizer rate on total number of tillers per plant of bread wheat in 2019 at Gito Kebele in Gechi ditrict.

	N (Kg/ha) Fertilizer rates			
NPSB (Kg/ha) Fertilizer Rates	**0**	**23**	**46**	**69**
0	1.00^{f}	1.33^{f}	1.33^{f}	1.33^{f}
50	2.00^{fe}	2.00^{fe}	3.00^{de}	3.33^{dc}
100	3.00^{de}	3.67^{dc}	4.00^{c}	4.33^{c}
150	4.00^{c}	5.00^{b}	5.67^{a}	6.00^{a}
LSD (0.05) NPSB*Urea = 0.65	CV(%) = 12.21			

Means followed by same the letter (s) are not significantly different at 5% P level of significance; NPSB= Nitrogen,Phosphorus, Sulfur and Boron blended fertilizer, CV (%) = Coefficient of variation; LSD (0.05) = Least SignificantDifference at 5% P level.

3.3.2. *Number of Productive Tillers Per Plant*

Number of productive tillers per plant was significantly (P<0.01) influenced by both main and interaction effect of NPSB and N fertilizer rates. Accordingly, the highest productive tiller (4.14) was recorded for combination of 150 kg/ha of NPSB and 69 kg/ha of N (Table 5). The lowest numbers of effective tillers (0.75) was recorded for the control plot.

In agreement with this result, Bereket *al et*, [17] have reported increases in the number of effective tillers with nitrogen fertilization. Bereket *al et*, [18] have also reported that nitrogen fertilization has significant effect on number of effective tillers of wheat. Similarly, the increase in the numbers of tillers in response to increasing rate of blended NPSB fertilizer indicated the importance of availability of balanced nutrients for better growth and development of wheat.

Table 4. Effect of NPSB and N fertilizer rate on number of productive tiller per plant of bread wheat in 2019 in Gechi ditrict, Ethiopia.

	N (Kg/ha) Fertilizer rates			
NPSB (Kg/ha) Fertilizer Rates	**0**	**23**	**46**	**69**
0	0.69^{f}	0.92^{f}	0.92f	0.92^{f}
50	1.38^{fe}	1.38^{fe}	2.07^{de}	2.3d^{c}
100	2.07^{de}	2.53d^{c}	2.76^{c}	2.99^{c}
150	2.76^{c}	3.45^{b}	3.91^{a}	4.14^{a}

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	N (Kg/ha) Fertilizer rates			
NPSB (Kg/ha) Fertilizer Rates	**0**	**23**	**46**	**69**
LSD (0.05) NPSB*Urea = 0.44	CV(%) = 12.21			

Means followed by the same (s) are not significantly different at 5% P level ; NPSB= Nitrogen, Phosphorus, Sulfur and Boron blended fertilizer, CV (%) = Coefficient of variation; LSD (0.05) = Least Significant Difference at 5% P level.

3.3.3. *Number of Spikelets Per Spike*

The result revealed that both NPSB and N rates had highly significant (P < 0.01) effect on the number of spikelets per spike of bread wheat. Similarly,the interaction of the two factors had significant effect on this parameter (Table 5). The largest number of spikelet per spike (23.12) was obtained from the application of maximum fertilizer rate (150/150 kg/ha of NPSB/ N), but it was statistically similar with the result obtained from application of 150/100 kg/ha of NPSB/urea. While, the smallest value (10.95) was obtained from application of 50 kg/ha of urea and the control plot (Table 6). In line with this, Iqbal *et al*. [19] have reported that number of spikelets per spike significantly increases with increasing rate of nitrogen.

Table 5. Effect of NPSB and N fertilizer rate on number of spikelets per spike of bread wheat in 2019 in Gechi ditrict, Ethiopia.

	N (Kg/ha) Fertilizer rates			
NPSB (Kg/ha) Fertilizer Rates	**0**	**23**	**46**	**69**
0	10.95^{fe}	11.56^{fe}	12.17^{e}	12.78^{e}
50	13.39^{e}	13.99^{d}	14.60^{d}	14.84^{d}
100	15.09^{d}	16.55^{dc}	17.04^{dc}	17.64^{dc}
150	17.04^{dc}	18.86^{c}	21.29^{b}	23.12^{a}
LSD (0.05) NPSB*Urea=1.32	CV(%) =6.15			

Means followed by the same letter (s) are not significantly different at 5% P level; NPSB = Nitrogen, Phosphorus, Sulfur and Boron blended fertilizer, CV (%) = Coefficient of variation; LSD (0.05) = Least Significant Difference at 5% P level.

3.3.4. *Grain Yield*

NPSB and N rates as well as their interactionsignificantly (P<0.01) affected grain yield of bread wheat (Table 5). Increasing the rates of the two fertilizers (NPSB and N) significantly increased grain yields. Thus,the highest grain yield (6.38 ton/ha) was obtained in response to the combined application of 150 kg/ha of NPSB and 69 kg/ha of N, whereas the lowest value (0.45 ton/ha) was recorded for the unfertilized plot (Table 7). The highest grain yield at the highest rates of NPSB and N might have resulted from improved root growth, increased uptake of nutrients and better growth due to interaction/synergetic effect of the four nutrients, which also enhanced the development of yield components.

Thus, the yield advantage was achieved due to the positive effect of blended NPSB and N fertilizers on total number of tillers, number of kernels per spike, spike length, and biomass yield. Application of nutrients like K, S, Zn, Mg and B significantly increased grain yield and yield component of bread wheat as compare to the control treatment [20]. In general, combined application of 150 kg/ha of NPSB and 69 kg/ha of N gave more than 10 folds grain yield over the control plot. Moreover, grain yield was highly and positively correlated with

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most of the growth parameters and yield components.

Table 6. Effect of NPSB and N fertilizer rate on grain yield of bread wheat in 2019 in Gechi ditrict, Ethiopia.

Treatment	**N (Kg/ha) Fertilizer rates**			
NPSB (Kg/ha)	**0**	**23**	**46**	**69**
0	0.45^{i}	1.14^{h}	1.68^{g}	2.04^{f}
50	1.09^{h}	2.46^{e}	3.66^{d}	4.55^{c}
100	1.67^{g}	2.77^{e}	3.94^{d}	4.97^{b}
150	2.22^{f}	3.57^{ed}	5.06^{b}	6.38^{a}
LSD (0.05) NPSB*Urea = 0.31	CV (%) = 6.16			

Means followed by the same letter (s) are not significantly different at 5% P level ; NPSB = Nitrogen, Phosphorus, Sulfur and Boron blended fertilizer, CV (%) = Coefficient of variation; LSD (0.05) = Least Significant Difference at 5% P level.

3.3.5. *Above Ground Biomass Yield*

Both the main effects of blended NPSB and N and their interaction were highly significantly ($P < 0.01$) and significantly ($P < 0.05$), respectively, for aboveground dry biomass yield of wheat (Table 7). The highest total aboveground dry biomass yield (10.73 ton/ha) was recorded for plants supplied with 150 kg of NPSB per ha combined with 69 kg/ha of N, followed by 150/46 and 150/23 kg of NPSB/N per ha with mean values of 9.47and 7.57 ton/ha, respectively (Table 8).

The lowest total aboveground dry biomass yield (1.5 ton/ha) was obtained from the control (unfertilized) plot. The increase in above ground dry biomass at the highest rates of NPSB and N might have resulted from improved root growth and increased uptake of nutrients, favoring better growth and delayed senescence of leaves of the crop due to synergetic effect of the four nutrients (NPSB). In agreement with this, Fageria *et al.* [20] have indicated that response to sulfur in NPSB fertilizer enhanced the photosynthetic assimilation of N in crops, which, in turn, increased the dry matter accumulation. Generally, total biomass yield increased at an increasing rate of fertilizers.

Table 8. Effect of NPSB and N fertilizer rates on abavegrund biomass yield of bread wheat in 2019 in Gechi district, Ethiopia.

Treatment	**Urea (Kg/ha)**			
NPSB (Kg/ha)	**0**	**23**	**46**	**69**
0	1.56^{l}	3.22^{j}	4.26^{i}	5.53^{g}
50	2.91^{k}	5.47^{g}	7.59^{d}	8.23^{c}
100	4.35^{i}	5.79^{f}	6.88^{e}	7.58^{d}
150	4.59^{h}	7.06^{e}	9.48^{b}	10.74^{a}
LSD (0.05) NPSB*Urea = 0.23	CV(%) = 2.28			

Means followed by the same letter (s) are not significantly different at 5% P level; NPSB = Nitrogen, Phosphorus, Sulfur and Boron blended fertilizer, CV (%) = Coefficient of variation; LSD (0.05) = Least Significant Difference at 5% P level.

3.3.6. *Straw Yield*

The result showed that straw yield of wheat was highly significantly ($P<0.01$) affected by NPSB and N rates.

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Similarily, the interaction of NPSB and N was highly significant (P<0.01) for straw yield (Table 8). Higher straw yield (4.45 ton/ha) was obtained from application of 150 kg/ha of NPSB plus 46 or 69kg/ha of N, whereas the lowest value (1.11 ton/ha) was recorded for the control plot (Table 8). The increase in straw yield in response to combined application of the highest rate of blended NPSB and N may be attributed to the synergetic roles of the four nutrients (NPSB) that played a significant role in enhancing growth and development of the crop. In line with this, Seyum [21] has reported increased straw yield of bread wheat with increasing NPSB and N fertilizer rates up to 200/92 kg/ ha.

Table 9. Effect of NPSB and N fertilizer rates on straw yield of bread wheat in 2019 in Gechi ditrict, Ethiopia.

Treatment	**N (Kg/ha) Fertilizer Rates**			
NPSB (Kg/ha)	**0**	**23**	**46**	**69**
0	1.11[ed]	2.08[d]	2.58[c]	3.49[ba]
50	1.82[d]	3.02[bc]	3.92[ba]	3.67[ba]
100	2.68[bc]	3.02[bc]	2.93[bc]	2.59[c]
150	2.37[c]	3.49[ba]	4.41[a]	4.35[a]
LSD (0.05) NPSB*Urea = 0.44	CV(%) = 8.87			

Means followed bythe same letter(s) are not significantly different at 5% P level; NPSB= Nitrogen, Phosphorus, Sulfur and Boron blended fertilizer, CV (%) = Coefficient of variation; LSD (0.05) = Least Significant Difference at 5% P level

3.3.7. *Harvest Index*

Harvest Index (HI) was highly significantly (P<0.01) affected by NPSB and N. Similerily,the interaction between NPSB and N was highly significant (P<0.01) (Table 9). An increasing trend of harvest index was observed in response to application of higher rates of NPSB and urea fertilizer. The highest HI (59.52%) was obtained with application of 150/69 kg/ha of NPSB/N, whereas the lowest value (28.85%) was recorded for the control plot (Table 10). The increment in harvest index at a higher rate of NPSB combined with N might be attributed to greater photo assimilate production and its ultimate partitioning into grains compared to the straw part, *i.e.* proportionally higher grain yield than vegetative biomass yield. On the other hand, low harvest index for the control (unfertilized) treatment might be associated with deficiency of nutrients and their in accessibility for the crop to use. Application of S, B with N, P increased yield components of wheat especially harvest index and grain yield [22].

Table 10. Effect of NPSB and N fertilizer rate on harvest index (%) of bread wheat in 2019 in Gechi ditrict, Ethiopia.

Treatment	**N (Kg/ha) Fertilizer Rates**			
NPSB (Kg/ha)	**0**	**23**	**46**	**69**
0	28.85[fed]	35.39[ced]	39.42[ced]	36.88[ced]
50	37.63[ced]	44.96[cbd]	48.37[cb]	51.51[b]
100	38.35[ced]	47.86[cbd]	57.36[b]	57.8[b]
150	48.46[cb]	50.57[cb]	53.48[cb]	59.52[a]

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Treatment	N (Kg/ha) Fertilizer Rates			
NPSB (Kg/ha)	0	23	46	69
LSD (0.05) NPSB*Urea = 5.6	CV (%) = 7.18			

Means followed by the same letter(s) are not significantly different at 5% P level ; NPSB= Nitrogen, Phosphorus, Sulfur and Boron blended fertilizer, CV (%) Coefficient of variation; LSD (0.05) = Least Significant Difference at 5% P level.

3.3.8. *Number of Grains Per spike*

The Main effect of NPSB and N highly significant (P<0.01) affects the number of grains per spike whereas their interaction did not significantly affect. It is evident from the data that maximum grain yield per spike (48.75) was produced with application of 150 kg/ha whereas the minimum number of grains per spike (38.58) was recorded at control plot of NPSB (figure 5). As reported by [14] genotypic difference of wheat affects yield and yield components rather than environment. It is clear from the data that number of grains per spike increased with increasing nitrogen levels generally.

In case of N application, the maximum number of grain per spike (46.17) was recorded at 69kg/ha while the minimum number of grains per spike (38.70) was recorded at control levels. However, at 46 and 69 kg/ha nitrogen levels the number of grains per spike were statistically similar. This can be justified with a reason that nitrogen availability satisfied the plant requirement for growth and development at 69 kg/ha, which enable the plants to produce more number of grains per spike. The findings are in line with the data reported by Wogene [14] who observed that increased application of nitrogen increases the number of grains yield per spike.

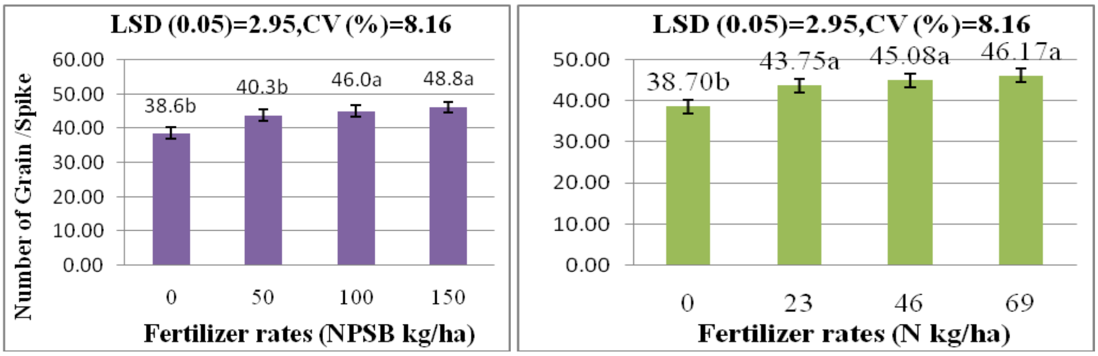

Fig. 2. Main affects NPSB and N on the number of grain per spike (No) Bars capped with same letter (s) are not significantly different at P = = 0.05 according to LSD test.

3.3.9. *Thousand Kernel Weight*

There was no significant effectof NPSB or Urea fertilizer as well as their interaction on thousand kernelweight. Thousand kernel weights is an important yield determining component a genetic character [23].

3.4. *Effect on Nitrogen Use Efficiency*

3.4.1. *Agronomic Efficiency*

Main and interaction effects of NPSB and Urea were highly Significant (p<0.01) for agronomic efficiency. Thus, the highest agronomic efficiency (66.52 kg/kg) was obtained from the lowest rate of 9.45 kg/ha of N, while the lowest agronomic efficiency of (23.04 kg/kg was recorded application of the highest rate 69 kg / ha of

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N (Figure 1).

The result of the present study showed that agronomic efficiency tended to decrease in response to higher rates of NPSB and N Fertilizer application. This suggests that application of excess nutrients was not effectively utilized by the crop and the rate of production was lesser per unit of nutrient applied. Tilahun and Alemayehu [24] reported agronomic efficiencyof applied Nitrogen exhibited a decreasing trend in response to higher Nitrogen application rates.

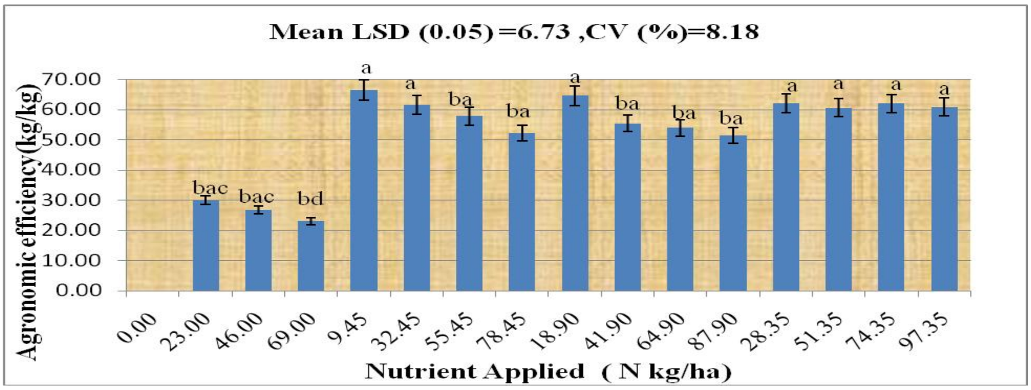

Fig. 3. Effect of N fertilizer rate on nitrogen agronomic efficiency at Gito Kebele in Gechi district during 2019 cropping season bars capped with same letter(s) are not significantly different at P = 0.05 according to LSD test.

3.4.2. *Physiological Efficiency*

Main and interaction effects of fertilizer treatments were significant for physiological efficiency (P<0.01). It was observed that application of 9.45 kg/ha N resulted in the highest physiological efficiency (118.95 kg /kg) whereas the application of 97.90kg/ha N fertilizers gave the lowest value (60.05kg/kg) (Figure 3). In line with this, Beyenesh *et al*. [25] have reported that physiological efficiency of wheat was found to reduce progressively as the rate of nitrogen application increased. The observed higher physiological efficiecncy at lower rates of fertilizer application might be due to relatively higher yield produced with low absorption of N. on the other hand, the lower physiological efficiecncy at higher fertilizer rates might indicate that the crop did not utilize the absorbed N for the production of maximum grain yield. This might be due to less efficient utilization of nitrogen for biomass and grain production with increasing N application levels [26].

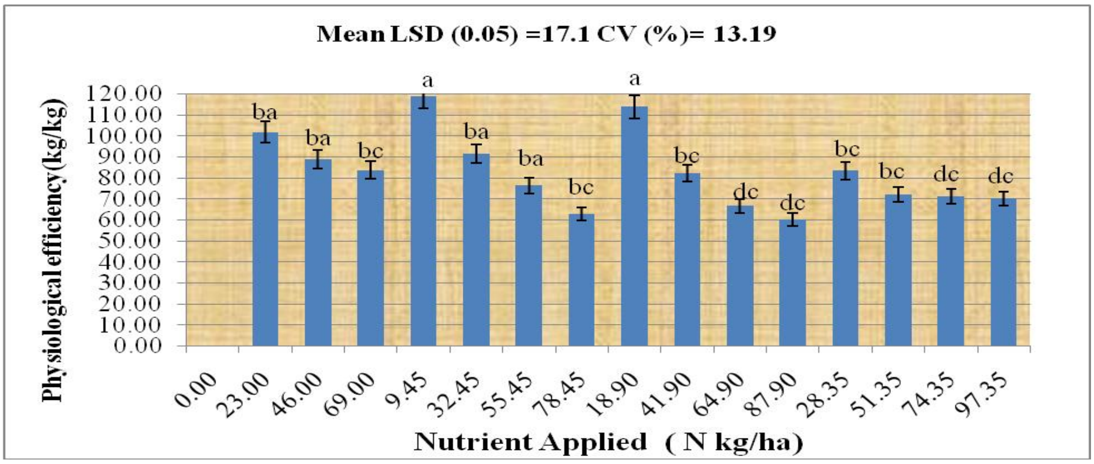

Fig. 4. Interaction effect of NPSB and Urea fertilizer rate on Nitrogen Physiological Efficiency at Gito kebele in Gechi district during 2019 cropping season. Bars capped with same letter(s) are not significantly different at P = 0.05 according to LSD test.

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3.4.3. *Apparent Recovery Efficiency*

Main and interaction effects of NPSB and Urea fertilizer were highly significant (p<0.01) for apparent recovery efficiency. The highest apparent recovery efficiency (149.04%) was obtained from 74.35 Kg/ha of N (Figur 7). However, the lowest apparent recovery (25.61%) was obtained from 87.90 Kg/ha of N. The recovery of any nutrient applied shows the nutrient supplying capacity of soil and the inherent capacity of the plant to utilize nutrients. In agreement with the present result, Sofonyas *et al.* (2016) [27] have reported that apparent recovery efficiency of wheat showed decreasing trend as N rates increase.

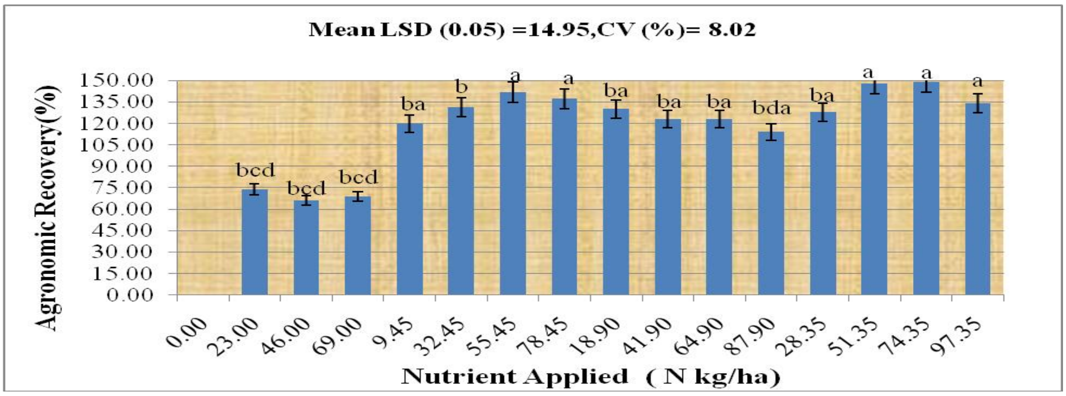

Fig. 5. Effect of N and NPSB fertilizer rate on nitrogen apparent recovery at Gechi district during 2019 cropping season bars capped with same letter(s) are not significantly different at P = 0.05 according to LSD test.

3.5. *Partial Budget Analysis*

The partial budget analysis of the treatments was done considered all variable costs and all benefits (grain yield and straw yield). The market price of Bread wheat grain and straw were 22.00 was 1.2ETB/kg, respectively. Fertilizer prices for NPSB and Urea were 19.80 and 17.89 ETB/kg, respectively. While the cost of other production practices like seed and weeding were assumed to be the same or insignificant among the treatments. Accordingly, the least total variable cost (TVC) was recorded for the control treatment (without fertilizer), while the highest net benefit (NB) was obtained in response to application of 150 kg/ha NPSB combined with 46 kg/ha N (100328.24 ETB/ha). The analysis of marginal rate of return (MRR), on the other hand, revealed that the rate of return per unit cost of production was highest for application of 150/46 kg/ha NPSB/N (% MRR =3321.93). This showed that it would yield 33.22 Ethiopian Birr for every Birr invested.

Thus, applications of 150 kg/ha of blended NPSB combined with 46kg/ha of Urea is economically beneficial as compared to the other treatments, because the highest net benefit(NB) and marginal rate of return (MRR) was above the minimum level (100%).This recommendation was also supported by CIMMYT (9), indicating that farmers should be willing to change from one treatment to another if the marginal rate of return of that change is greater than the minimum acceptable rate of return.

Table 13. Summary of partial budget analysis of for the effects of blended NPSB and UREA fertilizer rates on bread Wheat at Gito Kebele in Gechi district during 2019 cropping season.

NPSB (Kg/ha)	UREA (Kg/ha)	AGY (Kg/ha)	ASY (Kg/ha)	GFB (Birr/ha)	TVC (Birr/ha)	NB (Birr/ha)	MRR (%)
0	0	405	999	10108.8	0	10108.8	0
0	50	1026	1872	24818.4	894.5	23923.9	1544.45

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NPSB (Kg/ha)	UREA (Kg/ha)	AGY (Kg/ha)	ASY (Kg/ha)	GFB (Birr/ha)	TVC (Birr/ha)	NB (Birr/ha)	MRR (%)
0	100	1512	2322	36050.4	1789	34261.4	1155.67
0	150	1836	3141	44161.2	2684	41477.7	806.74
50	0	983.34	1635.66	23596.27	990	22606.27	D
50	50	2213.37	2714.13	51951.1	1885	50066.6	3069.91
50	100	3301.74	3529.26	76873.39	2779	74094.39	2686.17
50	150	4098.6	3303.9	94133.88	3674	90460.38	1829.62
100	0	1500.93	2414.07	35917.34	1980	33937.34	D
100	50	2493.45	2717.55	58116.96	2875	55242.46	2381.79
100	100	3552.12	2639.88	81314.5	3769	77545.5	2493.35
100	150	4479.03	2338.47	101344.82	4664	96681.32	2139.28
150	0	2000.88	2130.12	46575.5	2970	43605.5	D
150	50	3213.96	3142.44	74478.05	3865	70613.55	3019.35
150	100	4560.3	3967.2	105087.24	4759	100328.24	3321.93
150	150	5747.4	3916.2	131142.24	5654	125488.74	2812.8

Note:- Ad GY: Adjusted grain yield kg/ha, GB: Gross benefit, AdSY: adjusted Straw yield kg/ha,TVC:Total Variable Cost; NB: net benefit; MRR%: marginal rate of return,D:dominated,

IV. Conclusions

Wheat is an important food crop to Ethiopian people. However, the present production and productivity cannot gratify the farmers for the reason that wheat yields are very low in the country as compared to the world average. In Ethiopia, the blanket recommendations that are presently in use all over the country were issued several years ago, which may not be suitable for the current production. The present study was undertaken with the objectives of determining the effect of NPSB and N fertilizer rates on growth, yield and yield components of bread wheat and economically feasible rate of the fertilizers for optimum grain yield of the crop. Result revealed that days to heading, days to maturity,plant height and spike length were significantly affected by the main effect of NPSB and N whereas interaction effect of NPSB and N was not affected. The highest day to heading (64.58 days), days to maturity (122.17days) plant height (81.58cm) and spike length (6.69cm) were recorded at the highest rate of N fertilizer application (150 kg/ha). The maximum total tillers (6 plant), number of productive tiller (4.14), number of spikelet per spike (23.12), grain yield (6.38 ton/ha), above ground biomass yield (10.73 ton/ha), straw yield (4.35 ton/ha), harvest index (59%), number of seed per spike (44.5) and thousand kernels weight (40.00g) were obtained at combined application of 150 NPSB with 69kg/ha N. However, the NUE traits of bread wheat decreased as the nitrogen level applied to increase from lower to higher. With regard to partial budget analysis, combined application of 150 kg NPSB and 46 kg/ha N gave economic benefit of 100328.24 ETB/ha with the acceptable marginal rate of return (3321.93%) as compared to the other treatments in the study area. Application of 150 Kg/ha NPSB With combination of 46kg/ha N can be recommended for higher yield for the study area and it is also economically feasible. Thus, this rate of fertilizer

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would be recommended for the study area.

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