Plant
2025, Vol. 13, No. 2, pp. 100-107
https://doi.org/10.11648/j.plant.20251302.15

Research Article

Evaluation and Verification of the Type of Blended Fertilizer for Soil Fertility Based on the Soil Fertility Map Recommendations for Bread Wheat Production

Tesfaye Ketema Defar*, Mulugeta Eshetu Diriba, Regassa Gosa Telila, Girma Getachew Gemechu

Oromia Agricultural Research Institute, Sinana Agricultural Research Centre, Soil Fertility Improvement Team, Bale-Robe, Ethiopia

Abstract

Ethiopia's economy and professions have traditionally depended on agriculture, emphasizing the need to provide the most appropriate fertilizer packages for various crops, especially to enhance the productivity of the country's small-scale farmers. A field study was conducted during the 2020–2023 cropping season in southeastern Ethiopia's Bale Highland and West Arsi Zone. This study utilized a randomized complete block design (RCBD) with five treatments and three replicates to assess different types of balanced fertilizers and confirm recommendations based on soil fertility maps for bread wheat production. The treatments included: 1) Control (no fertilizer); 2) 100 kg/ha of urea; 3) 100 kg of urea plus 100 kg of NPS/ha; 4) 100 kg of urea plus 100 kg of NPSB/ha; and 5) 100 kg/ha NPSZnB plus 100 kg of urea. Using blended fertilizers yielded significant enhancements in plant height, the number of tillers per plant, spike length, seeds per spike, grain yield, above-ground biomass, and the weight of a thousand kernels at harvest.

Keywords

Balanced Fertilizer Type, Fertilizer Type, Ata Mapping, *Bale*, *West Arsi*, *Biomass*

1. Introduction

Wheat (Triticum spp.) is Ethiopia's main highland cereal grain crop [13, 16] Wheat can withstand clay loam and silts with a satisfactory drainage system but can also withstand varied soils [3]. Wheat ranks third in cereal grain production in Ethiopian agriculture with a 15.17% contribution (4,642.96 million tons) and fourth in the area covered by cereal grains with a 13.38% contribution (1.69 million hectares) after maize and teff [6, 10].

Despite its large cultivated land, long production history, and contribution to Ethiopian agriculture, wheat yields are low, with an average highest record of 2.74 tons per hectare [6, 4] compared to a world average record of 3.0 tons per hectare [15, 17] Low yields and low productivity can be attributed to factors such as low soil fertility and other abiotic and biotic factors.

Soil barrenness, agronomic and technological innovation, and the improvement of superior technology are the largest discouragements of Ethiopia's superior bread-wheat production. According to [11] the key drivers of Ethiopian bread wheat production are sluggish development of wheat with long-lasting

*Corresponding author: tesfayeke33@gmail.com (Tesfaye Ketema Defar)

Received: 11 February 2025; **Accepted:** 27 March 2025; **Published:** 23 June 2025

resistance to pests, disease, and weeds and poor soil fertility.

We find that the supply of balanced feeding and sustained nitrogen release through organic material enhanced microbial growth and soil quality [22]. As per [31, 25] balance in utilizing organic and inorganic fertilizer materials is what is required to enhance the fertility of the soil. The use of inorganic fertilizers has been instrumental in solving soil fertility issues and contributing enormously to the higher production of food globally [26]. Fertilizers have accounted for a minimum of 30 to 50 percent of crop yield improvement [28].

Plants need adequate quantities of major nutrients to achieve their full potential [31]. In Ethiopia, nonetheless, diammonium phosphate (DAP) and urea were the sole crop productivity inputs that had been utilized for a very long time. To rectify the main nutrient deficiencies in Ethiopian soils, as noted by [2] other than nitrogen and phosphorus, other nutrients such as sulfur, potassium, boron, zinc, and copper are required. Soil in the study area is poor in primary macronutrients like nitrogen and phosphate, secondary macronutrients like sulfur, and some micronutrients, particularly boron. Otherwise, most of the Bale and West Arsi highlands soil was poor in the aforementioned nutrients [2] The majority of Ethiopian soils are deprived of an average of seven nutrients (N, P, K, S, Cu, Zn, and B) from the soil fertility map that encompasses more than 150 districts [14, 2].

Balanced fertilization is achieved through healthy soil and crop harvesting sustainably. Since there was no substitute to control soil fertility and use balanced types of fertilizer, bread wheat production declined in the study area. Balanced fertilizer use is the solution to enhancing soil fertility and bread wheat production in the study area, but nothing has been found about the type of balanced fertilizers that are suggested based on the ATA soil fertility map. The fertilizer type should be used in an attempt to enhance the fertility of bread wheat and soil within the study area.

It is not determined yet for bread wheat types how soil analysis based on balanced mixed fertilizer treatment levels can provide the highest grain and quality. For optimal bread wheat yield in the study area, the study tried to evaluate a soil fertility map based on different balanced applications of fertilizer for bread wheat growth in the study area and recommend an alternative balanced fertilizer source.

2. Materials and Methods

2.1. Description of the Study Area

The research was done in the Bale highland Sinana, Goba, and Agarfa district and from West Arsi Zone Adaba and Dodola woredas of the southeast Ethiopian (Figure 1). The study area highlands in the Bale and West Arsi Zones form a range of agroecology. The principal season, which runs from August to December and gets between 270 and 560 millimeters of rainfall, and the short season, which runs from April to July and gets between 250 and 560 millimeters of rainfall, are the two rainy seasons in the area. The months from December to March are the driest.

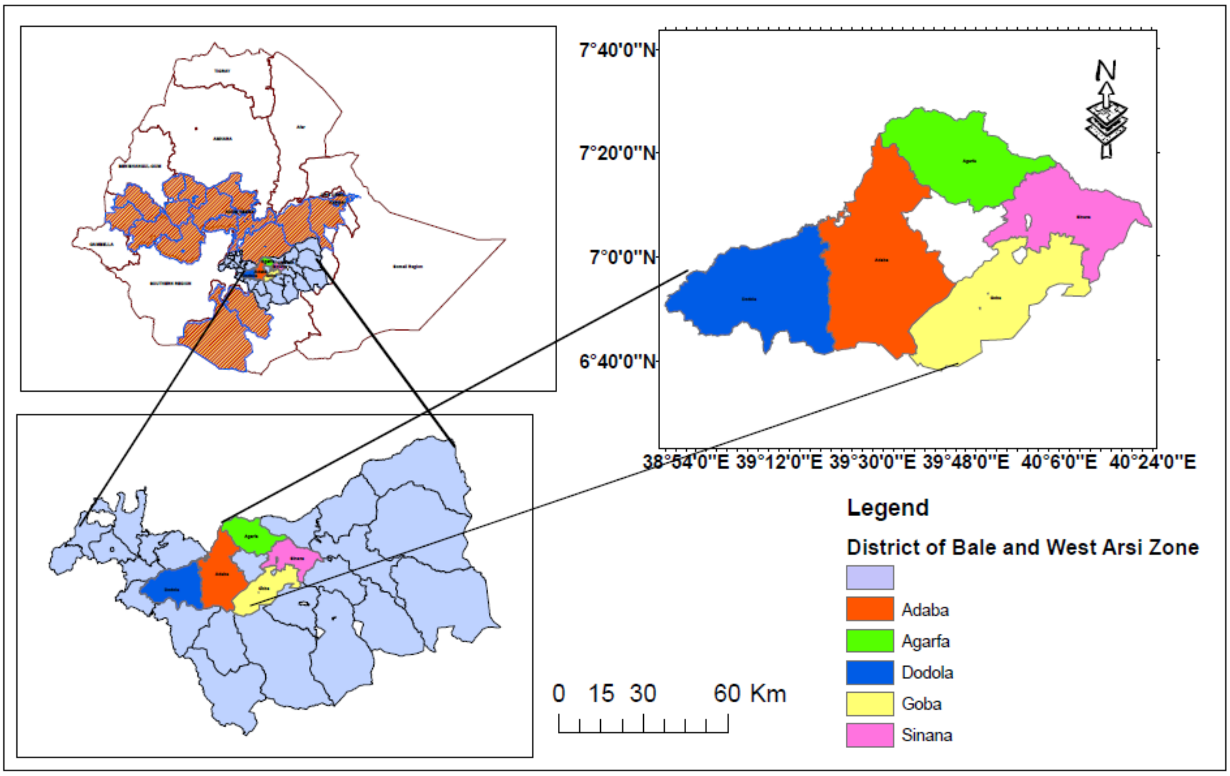

Figure 1. *Map of the study area.*

2.2. Experimental Design and Treatments

Between 2020 and 2023, the trial was conducted in West Arsi and Bale Highland areas. The trial was obtained from treatments for ATA mapping for Bale high (Sinana, Arafa, and Goba) from West Arsi (Adaba and Dodola) and was based on Randomized Complete Block Design (RCBD). Three replications per treatment were used.

There were fifteen plots with five treatments, and each treatment was replicated three times.

The planting soil mix rows received a full application of NPS, NPSB, and NPSZnB. The two nitrogen applications were applied at planting and, in addition, thirty-five days later.

All the management practices were adopted as recommended by wheat research, and Mandau's new wheat variety was employed in the experiment. All the respective agronomic and soil data were collected at various stages of the respective crop growth using the recommended practices.

The experiment consists of five treatments

T1 = Control (without fertilizer)

T2 = 100 kg/ha Urea

T3 = 100 kg /ha NPS+100 kg/ha Urea

T4 = 100 kg /ha NPSB+100 kg/ha Urea

T5 = 100 kg /ha NPSZnB+100 kg/ha Urea

2.3. Data Collection and Soil Sampling

Various methods are used in yield and yield trait data collection. Five random plants in the middle row of each plot measure plant height. To calculate grain yield and also biomass, the whole net plot is harvested and then converted into kilograms per hectare. A random sample of 1,000 grains is taken from the overall grain yield and weighed in a precision balance, and the measurement is recorded in grams. Spike length, seeds per spike, and tillers per plant are the other parameters that are recorded.

The trial plot also receives random soil sampling before and after planting as deep as 0–20 cm. Sieving through 2 mm mesh except for the organic matter samples, crushing, and air-drying are applied to the samples. The latter is taken to the Sinana Agricultural Research Center and analyzed according to standard laboratory procedure.

2.4. Soil Sample Analysis

Organic carbon was determined by the Walkley and Black oxidation technique [23], while total nitrogen was determined by the sulfuric acid digestion and the micro-Kelshall technique [20]. Available phosphorus was determined by Olsen's method [24] with a spectrophotometer and soil pH using a 1: 2.50 soil-to-water ratio [29].

Soil texture was analyzed by the hydrometer method of [5]. Exchangeable bases (Ca, Mg, K, and Na) were analyzed after extracting with 1 molar ammonium acetate (NH_4OAc) solution at pH 7.0 and then estimating. Cation exchange capacity (CEC) was measured by percolating ammonium acetate-extracted soil samples with 10% NaCl solution and estimating ammonium ion concentration in the percolate by the Kjeldahl method [8]. Percent base saturation (PBS) was calculated as the total exchangeable bases divided by the soil CEC. The fertility level of the soils of the experimental field was quantified by relating laboratory-measured values of the physical and chemical properties to ratings or critical levels established for the various classes of soil parameters.

2.5. Data Analysis

Data acquired from R-Software was subjected to analysis of variance (ANOVA) based on experimental design. Means were divided by the Least Significant Difference (LSD) at ($p>0.05$) levels of significance. Pearson correlation was applied to establish linear relationships between agronomic factors. Interpretation of guidelines for soil nutrients was used in an attempt to further stratify soil analysis results, and general results were given based on descriptive statistics.

3. Results and Discussion

3.1. Soil Fertility Status Before Planting

Composite soil samples of the top 20 cm layer of each experimental plot were collected before the initiation of planting. Table 1 provides some of the general chemical characteristics of the soil at these locations. Experimental field soil texture is predominantly clay, which indicates the degree of weathering on geologic scales and the soil's capacity for water and nutrient retention. As indicated in the table, the pH of the soil at both locations varied from 6.01 to 6.8. [19] refers to this pH as neutral, which is suitable for the growth of most crops since plants thrive in pH levels varying from 6.01 to 7.05. The concentration of Soil Organic Matter at the points of sampling varied from 1.45 to 2.83 at both locations (Table 1). This is low to moderate according to the rating by [29]. The soil total nitrogen content ranged from 0.10 to 0.18 between locations. [21] cited that they provided low total nitrogen contents in the experimental location. The content of available phosphorus ranged from 1.18 to 5.92 in the two locations (Table 1). All the tested soils had low phosphorus according to the classification system by [9] The soil in the study sites received a moderate to high grade according to [19] cation exchange classification system.

Table 1. *Physico-chemical soil properties of the study area.*

Location	Textural type	PH (H_2O)	OM (%)	TN%	P (mg/kg)
Sinana	Clay	6.2-6.7	1.45-1.93	0.18	1.18-4.45
Gobba	Clay	6.01	1.61	0.16	5.92
Agarfa	Clay	6.02-7.05	1.80-2.56	0.15	3.88-5.72
Dodala	Sandy Clay	6.79-7.2	2.12-2.73	0.12	1.23
Adaba	Clay	6.48-6.8	1.93-2.83	0.10	1.31

3.2. Growth Parameters

3.2.1. Plant Heigh

According to analysis of variance statistics, the application of different quantities and levels of mixed fertilizer significantly affected ($p>0.05$) wheat plant height. In Bale Highland, 100-kilogram NPSB + 100 kg/ha^{-1} urea produced the highest plant height (92.27 cm), whereas in West Arsi, 100 kg NPS + 100 kg/ha^{-1} urea produced the highest plant height (88.83 cm). Whereas the other treatments had no statistically significant differences, control plots had the lowest plants in both regions with 84.87 cm and 77.46 cm heights in Bale Highland and West Arsi, respectively (Tables 2 and 3).

The increased plant height may be a result of higher N use during the vegetative growth and elongation phases of wheat. Conversely, reduced plant height in the control plots may be a consequence of the inferior soil fertility of the experimental plots. These findings are in line with [7], who recorded significantly taller bread wheat plants after applying 300 kg of NPSZn-blended fertilizer per ha^{-1} as compared to the unfertilized treatments. Similarly, [18, 30]. found that 200 kg NPS kg/ha^{-1} mixed fertilizer treatment produced the tallest plants (118.06 cm), while the control treatments produced the shortest plants (86.2 cm).

3.2.2. Spike Length

Relative to the control plot, the type and rate of blended fertilizers applied had a large ($p>0.05$) effect on the spike length of wheat. The control plot of Bale Highland and West Arsi resulted in minimum spike lengths of 6.27 cm and 4.62 cm, respectively, whereas applying 100 kg NPSZnB + 10 kg/ha^{-1} urea from Bale Highland and West Arsi had maximum spike lengths of 7.13 cm and 6.67 cm, respectively (Tables 2 and 3). However, a non-significant difference was evident in the mixture of fertilizer. [18] also reported the same results, where the 200 kg NPSB kg/ha^{-1} mixed fertilizer produced the highest spikes (9.37 cm), and the lowest spikes (6.14 cm) were noted in the control (unfertilized) treatment. According to [3, 30], the increase in spike length with the mixed fertilizer treatment could lead to higher photoassimilation. The author continued to say that when the spike length was increased, the grain per spike was maximized, leading to a higher yield.

3.3. Yield and Yield Components

3.3.1. Number of Tillers Per Plant

Relative to control plots, the use of mixed fertilizer type and rate significantly ($p>0.05$) changed tiller per plant numbers. Application of 100 kg/ha^{-1} NPSB + 100 kg ha^{-1} urea and 100 kg/ha^{-1} NPSZnB + 100 kg/ha^{-1} urea provided the highest number of tillers per plant at Bale Highland (4.09) and West Arsi (4.25). The two study location sites' unfertilized plots, however, had the least tillers per plant (3.13) and (3.71), as is the case in Tables 2 and 3. This concurs with [27] study, where the superiority of the best application rate of nitrogen on tillering was substantiated through the discovery that the blend of 200 kg NPS + 92 kg N ha^{-1} yielded the greatest number of tillers per bread wheat plant.

3.3.2. Number of Seeds Per Spike

The variance analysis detected a statistically significant (P 0.05) difference in seeds per spike among the blended fertilizer rates and types that were supplied. The highest seeds per spike (42.38) and the lowest (38.21) were yielded in the West Arsi and Bale highlands, respectively, by the plot that received 100 kg/ha^{-1} urea and 100 kg/ha^{-1} NPSZnB, whereas the control treatment yielded the lowest seeds per spike (33.08) and the lowest seeds (38.21) (Tables 2 and 3). Compared to the control treatments, seeds per plant increased by 62% with the application of the highest rate of NPS mixed fertilizer. [1, 30] found that the control plot produced the highest number of seeds (50.47) and the lowest (32.73) per wheat spike with the application of NPSZnB kg ha^{-1} fertilizer.

3.3.3. Thousand Kernel Weight

Analysis of variance revealed that the varying blended fertilizer type and rates were not statistically different in thousand kernel weight ($p>0.05$). Both test sites' maximum thousand kernel weight was found from 100 kg/ha^{-1} NPSB (Tables 2 and 3), over 27% higher than the control plot. Of the 1000 kernels, the fertilized plot was the heaviest (44.8 g), and the unfertilized plot was the lightest (37.2 g), as reported by [12]

This is consistent with their research.

3.3.4. Above Ground Biomass

The application of mixed fertilizer rates significantly (p>0.05) affected the aboveground biomass than the control. The highest aboveground biomass (14054.67 kg ha^{-1}) in West Arsi and Bale highlands was obtained by 100 kg/ha^{-1} NPSB + 100 kg/ha^{-1} urea, and the highest aboveground biomass (13998.12 kg) was obtained by 100 kg/ha^{-1} NPS 100 kg/ha^{-1} urea. On the contrary, Tables 2 and 3 show that the control recorded the least aboveground biomass in the study areas ranging from 9080.98 kg ha^{-1} to 11167.79 kg ha^{-1}. With the use of 100 kg/ha^{-1} NPSB + 100 kg/ha^{-1} urea, Bale Highland and West Arsi have aboveground biomass increased by 64.61% and 79.8%, respectively, when compared with the control treatment. Enhanced root development and increased nutrient storage, which can enhance better growth and tillering, may cause enhanced aboveground biomass, hypothesize [12, 1] state that the treatment that was given NPSZnB yielded the highest total biomass (14290 kg ha^{-1}), and the control yielded the lowest (3390 kg ha^{-1}).

3.3.5. Grain Yield

Values in Tables 2 and 3 of the analysis of variance indicated that the various forms of blended fertilizer significantly (p>0.05) influenced grain yield production. The experiment determined that although a maximum grain yield of 4661.96 kg ha^{-1} was produced in the plots fertilized with 100 kg NPS + 100 kg urea in West Arsi, a maximum grain yield of 5257.57 kg ha^{-1} was attributed to the plots sown by 100 kg ha^{-1} NPSZnB + 100 kg ha^{-1} urea in the bale upland. The minimum was from West Arsi and Bale Highland and amounted to 2215.71 kg ha^{-1} and 3006.51 kg ha^{-1}, respectively (Tables 2 and 3).

100 kg NPSZnB + 100 kg urea ha^{-1} increases the grain yield of the bread wheat crop by 57.2% to that of an unfertilized crop in Bale Highland. Moreover, compared with the control plot, the application of 100 kg NPS + 10 kg urea in West Arsi increases the bread wheat grain yield by 47.5%. Maximum grain yield from maximum NPS levels with maximum levels of nitrogen would be attributed to enhanced root development and better uptake of nitrogen, leading to more yield and components of yield. [1] also arrived at the same conclusion and stated that NPSZnB kg ha^{-1} treatment resulted in maximum grain yield (5770 kgha^{-1}) and the lowest grain yield was recorded for unfertilized plots.

Similarly, [12] also proved that the treatments with a combination of fertilizers with 183 kg ha^{-1} NPSB produced greater wheat grain than the control. [30, 7] cite 200 kg of NPSZnB fertilizer to be used on the unfertilized plot to obtain maximum wheat grain yield (3580.2 kg ha^{-1}).

Table 2. Mean wheat yield and yield components as influenced by different blended fertilizer types in Bale Highland.

Trt (Combined)	PH (cm)	SL (cm)	SPS (cm)	NT	BM (kg)	GY (kg)	TKW
Control	84.87^{b}	6.27	38.84^{c}	3.13	9080.98	3006.51^{e}	30.11
100 kg Urea	89.22^{a}	7.07	39.82^{bc}	3.42	9607.42	3838.87^{d}	32.89
100 kg NPS +100 Urea	92.11^{a}	6.58	40.82^{ab}	4.00	11701.27	4593.89^{c}	32.69
100 kg NPSB +100 Urea	92.27^{a}	6.71	40.27^{bc}	3.96	14054.67	5005.38^{b}	33.07
100 kg NPSZnB +100 Urea	91.20^{a}	7.13	42.38^{a}	4.09	12054.27	5257.51^{a}	32.69
Mean	89.93	6.75	40.43	3.72	11299.72	4340.43	32.89
LSD (0.05%)	4.0	NS	1.7	NS	1212	232.4	NS
CV (%)	10.96	13.64	10.65	20.62	15.82	12.89	12.65

NB. At the 5% level of significance, means that share the same letter are statistically not significant. LSD stands for least significant difference, and CV for coefficient of variation. Plant height is denoted by PH, thousand kernel weight by TKW, seed per spike by SPS, spike length by SL, number of tillers by NT, biomass by BM, and grain yelled by GY.

Table 3. Mean wheat yield and yield components as influenced by different blended fertilizer types in West ARSI.

Trt (Combined)	PH (cm)	SL (cm)	SPS (cm)	NT	BM (kg)	GY (kg)	TKW
Control	77.46^{b}	4.62	33.08	3.71	11167.79	2215.71^{c}	26.21
100 kg Urea	81.21^{b}	6.21	35.00	3.50	13519.00	3235.88 ^{b}	27.54

Trt (Combined)	PH (cm)	SL (cm)	SPS (cm)	NT	BM (kg)	GY (kg)	TKW
100 kg NPS +100 Urea	89.17[a]	6.67	37.08	3.96	13998.12	4661.96[a]	27.58
100 kg NPSB +100 Urea	88.83[a]	6.58	37.83	4.25	12745.33	4506.29[a]	27.67
100 kg NPSZnB +100 Urea	87.38[a]	6.67	38.21	4.08	12601.79	4580.71[a]	27.29
Mean	84.81	6.15	36.24	3.90	13386.41	3840.11	27.66
LSD (0.05%)	4.3	NS	2.4	NS	1123	251	NS
CV (%)	8.94	17.56	11.60	21.23	14.68	11.44	13.00

NB: At the 5% level of significance, means that sharing the same letter is statistically not significant. LSD stands for least significant difference, and CV for coefficient of variation. Plant height is denoted by PH, thousand kernel weight by TKW, seed per spike by SPS, spike length by SL, number of tillers by NT, biomass by BM, and grain yelled by GY.

3.4. Correlation Analysis

Tables 4 and 5 present the findings of the analysis conducted to determine the correlation between bread wheat development and yield components as influenced by the application of mixed fertilizers. There was a positive and significant relationship between grain yield and other yield components. Therefore, whenever such traits are enhanced, bread wheat grain yield will always increase. The plant tillers per plant, plant height, spike length, seeds per spike, above-ground biomass, and thousand kernel weight all had a high positive correlation with grain yield in West Arsi and Bale highland (0.08*,0.59**,0.50**,0.45*, -0.16*, and -0.11*), respectively (r= 0.31*, 0.41*, 0.33*, 0.30*, and 0.07*). West Arsi thousand kernel weight and above-ground biomass were negatively related, whereas some positively correlated with grain yield.

Findings indicated that fertilizers exerted significant and positive effects on bread wheat production. Tillers per plant, plant growth, spike length, seeds per spike, above-ground biomass, and weight of one thousand seeds have all been validated in association with grain yield in bread wheat from the latest research carried out by [1, 30].

Table 4. *Correlation coefficients between mean agronomic parameters of Bread wheat grown under blended fertilizers in Bale Highland.*

	TKW	BM	GY	SL	SPS	NT	PH
TKW	1						
BM	0.006*	1					
GY	0.07*	0.53**	1				
SL	0.08*	0.20*	0.33*	1			
SPS	0.17*	0.20*	0.30*	0.18*	1		
NT	0.14*	0.41**	0.31*	0.22*	0.20*	1	
PH	-0.16*	0.43**	0.41*	0.33*	0.23*	0.15*	1

Note: Plant height (PH), Thousand Kernal Weight (TKW), Seed Per Spike (SPS), Spike Length (SL), Number of Tilers (NT), Biomass (BM), GY (grain yelled), and Significant Difference (NS) (1%, 5%, respectively) are indicated by the symbols * and **.

Table 5. *Correlation coefficients between mean agronomic parameters of Bread wheat grown under blended fertilizers in West Arsi.*

	TKW	GY	BM	SL	SPS	NT	PH
TKW	1						
GY	-0.11*	1					
BM	0.39**	-0.16*	1				
SL	-0.38*	0.50**	-0.29*	1			
SPS	-0.049*	0.45*	-0.05	0.08*	1		
NT	0.50*	0.08*	0.11	-0.38*	0.27*	1	
PH	-0.57*	0.59**	0.35	0.68**	0.24*	-0.42*	1

Note: Plant height (PH), Thousand Kernal Weight (TKW), Seed Per Spike (SPS), Spike Length (SL), Number of Tilers (NT), Biomass (BM), GY (grain yelled), and Significant Difference (NS) (1%, 5%, respectively) are indicated by the symbols * and **.

4. Conclusion and Recommendations

The findings of the study revealed that the application of NPSZnB in Bale Highland and NPS in West Arsi balanced fertilizer types had the highest variation (p>0.05) among the other four fertilizer types applied. When wheat production in Bale Highland was increased with the use of NPSZnB fertilizers (a combination of zinc and boron with the macronutrient NPS), wheat yield and yield characteristics were much higher in these two fertilizer types than in the other three. West Arsi was also provided with NPS mixed fertilizer. Misuse and/or insufficiency in the use of inorganic fertilizers is among the primary reasons for low crop yields and nutrient depletion. Replace any lacking fertilizers based on nutritional requirements. Soil testing is a useful way of improving farm yields and production sustainably. After determining which nutrients are lacking in the soil, the Agricultural Transformation Agency (ATA) created several fertilizers for the country during the past five to eight years so farmers can move from using urea to diammonium phosphate. More combined and balanced macro and micro fertilizers. Nutrients). According to reports, micronutrient deficiencies of Cu, Mn, B, Mo, and Zn, as well as minerals K, S, Ca, and Mg, have resulted in a widespread shortage of major crops in the nation. Rising combined fertilizer application rates optimized biomass and grain yields. According to the research findings, application of fertilizer is a viable option for increasing crop yield and biomass in the study region. The yield of wheat was increased through the application of nitrogen fertilizer but decreased with phosphorus and potassium fertilizers. The research findings show that different species of crops and soils call for varying intensities of application of fertilizer. NPSZnB is widely applied by farmers in Bale Highland to boost wheat production in the study area, and NPS for West Arsi zones is compatible with most fertilizers. The kind and quantity of mixed fertilizer used here would be useful in other agroecology with similar compositions too.

Abbreviations

N	Nitrogen
P	Phosphors
K	Potassium
S	Sulfur
Cu	Coper
Zn	Zinc
B	Boron
OM	Organic Mater
TN	Total Nitrogen
CEC	Cation Exchange Capacity

Disclaimer (Artificial Intelligence)

During the creation and editing of this publication, the authors hereby declare that no generative AI tools, including text-to-image generators and large language models (ChatGPT, COPILOT, etc.), were employed.

Conflict of Interest

The authors declare no conflicts of interest.

References

[1] Abebual Woldetsadik, Wondwosen Tena, and Asmare Melese. 2019. Effect of Different Blended Fertilizer Formulation on Yield and Yield Components of Bread Wheat (Triticum aestivum L.) in Siyadebrenawayu District, North Shewa, Ethiopia. Journal of Biology, Agriculture and Healthcare, 9 (15): 13-23.

[2] ATA (Agricultural Transformation Agency). 2016. Soil Fertility Status and Fertilizer Recommendation Atlas of the Southern Nations Nationalities and Peoples' Regional State, Ethiopia, by Ministry of Agriculture and Natural Resources and Agricultural Transformation Agency, Ethiopian, Addis Ababa, Ethiopia.

[3] Bekele Hundie, Mawangi W and Tanner DG. 2000. Adaptation of improved wheat technologies in Addaba and Dodola woredas of the Bale high lands of Ethiopia CIMMYT/EARO, Addis Ababa, Ethiopia. Bread wheat cultivars were released in Ethiopia from 1949 to 1987.

[4] Berhan Abayu. 2012. Agronomic and Economic Effects of Blended Fertilizers under Planting Method on Yield and Yield Components of Tef: MSc Thesis, Mekelle University, Mekelle, Ethiopia.

[5] Bouyoucos, G. J. (1952). A recalibration of the hydrometer method for making mechanical analysis of soils.

[6] Central Statistical Agency (CSA) (2018) The Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey. Report on Area and Production of Crops. Statistical Bulletin No. 586. Addis Abeba, Ethiopia.

[7] Dargie, S., Hadgu, F., Brhane, H., Mehari, T., Hadis, M., Hailu, G., & Berhe, D. (2021). Evaluation of NPSZn Blended Fertilizer on Yield and Yield Traits of Bread Wheat (Tritcum aestivum L.) on Cambisols and Vertisols in Southern Tigray, Ethiopia. *Ethiopian Journal of Agricultural Sciences*, *31*(2), 33-43.

[8] Chapman, H. D. (1965). Cation‐exchange capacity. *Methods of soil analysis: Part 2 Chemical and microbiological properties*, *9*, 891-901.

[9] Cottenie, A. (1980). Soil and plant testing as a basis of fertilizer recommendations. FAO soil bulletin 38/2. Food and Agriculture Organization of the United Nations, Rome.

[10] CSA (Ethiopian Central Statistical Agency). 2012. Structural transformation in Ethiopia: Evidence from cereal markets, International Food Policy Research Institute (IFPRI).

[11] Demeke, M., Di Marcantonio, F., & Morales-Opazo, C. (2013). Understanding the performance of food production in sub-Saharan Africa and its implications for food security. *Development and Agricultural Economics*, *5*(11), 425-443.

[12] Dinkinesh Abera, Tamado Tana and Tadesse Dessalegn. 2020. Effects of blended NPSB fertilizer rates on yield and grain quality of durum wheat (Triticum turgidum L.) varieties in Minijar Shenkora District, Central Ethiopia. Ethiopian Journal of Agricultural Sciences, 30(3): 57–76.

[13] Efrem Bechere, Hirut Kebede and Getachew Belay. 2000. Durum wheat in Ethiopia: An old crop in an ancient land. Institute of Biodiversity Conservation and Research. Addis Ababa, Ethiopia.

[14] EthioSIS (Ethiopian Soils Information System). 2013. Status of soil resources in Ethiopia and priorities for sustainable management, GSP for eastern and southern Africa Mar 25-27, 2013 Nairobi, Kenya.

[15] FAO (Food and Agricultural Organization). 1998. Ethiopia: Soil Fertility Initiative, concept paper, Report No. 98/028 CP-ETH, FAO/World Bank Cooperative Program. FAO, Rome.

[16] FAO AND ITPS. 2015. Status of the World Soil Resource (SESR)-main report, pp. 132.

[17] FAOSTAT (The Food and Agriculture Organization Corporate Statistical Database). 2013. Agricultural production Statistics. http://www.fao.org/faostat

[18] Haji Jewaro Beketa, Demelash Kefale and Tarekegn Yoseph. 2020. Effect of Blended Fertilizer Types and Rates on Growth, Yield and Yield Components of Bread Wheat (Triticum aestivum L.) in Wondo District, Southern Ethiopia. International Journal of Agriculture Innovations and Research, 8(4): 326-342.

[19] Hazelton. (2007). *Interpreting Soil Test Results*, CSIRO Publishing, 150 Oxford Street (P O Box 1139) Collingwood VIC 3066, Australia.

[20] Jackson, M. L. (1962, February). Interlayering of expansible layer silicates in soils by chemical weathering. In *Clays and Clay Minerals (National Conference on Clays and Clay Minerals)* (Vol. 11, pp. 29-46). Cambridge University Press & Assessment.

[21] Landon, J. R. (1991). Booker Tropical Soil Manual: A handbook for soil survey and Agricultural Land Evaluation in the Tropics and Subtropics. Longman Scientific and Technical, Essex, New York. 474p. OR John Wiley & Sons Inc., New York.

[22] Meshram, P., P. Bagade, S. Bachhav, Y. Shaniware and R. Shirsath. (2024). Influence of different sources and levels of phosphorus on growth and nutrient uptake of soybean in low calcareous soil. *International Journal of Statistics and Applied Mathematics*, 9(6): 104-108. https://doi.org/10.22271/maths.2024.v9.i6Sb.1895

[23] Walkley, A., & Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil science*, *37*(1), 29-38.

[24] Olsen, S. R. (1954). *Estimation of available phosphorus in soils by extraction with sodium bicarbonate* (No. 939). US Department of Agriculture.

[25] Roy, R. N., Misra, R. V, Lesschen, J. P. &Smaling, E. M. A. 2003. Assessment of Soil Nutrient Balance: Approaches and Methodologies. Rome, FAO.

[26] Sanchez, P. A., Shepherd, K. D., Soule, M. J., Place, F. M., Buresh, R. J., Izac, A. M. N., ... & Woomer, P. L. (1997). Soil fertility replenishment in Africa: an investment in natural resource capital. *Replenishing soil fertility in Africa*, *51*, 1-46.

[27] Seyoum Alemu. 2017. Effect of blended NPS and N fertilizer rates on yield components, yield, and grain protein content of bread wheat (Triticum aestivum L.) in Bore district, Guji Zone, Southern Ethiopia. MSc Thesis. School of Plant Sciences, Haramaya University, Ethiopia.

[28] Stewart, I. T., Cayan, D. R., & Dettinger, M. D. (2005). Changes toward earlier streamflow timing across western North America. *Journal of Climate*, *18*(8), 1136-1155.

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

[30] Tesfaye Ketema Defar, Mulugeta Eshetu Diriba, Regassa Gosa Telila, Girma Getachew Gemechu (2024). Evaluation of Balanced Fertilizer Types and Validation of Soil Fertility Map-Based Fertilizer Recommendation for Bread Wheat Production in Bale Highland Southeastern Ethiopia. *Cross Current Int J Agri Vet Sci*, *6*(3), 40-46.

[31] Teklu, E., & Hailemariam, T. (2009). Agronomic and economic efficiency of manure and urea fertilizers use on vertisols in Ethiopian highlands. *Agricultural sciences in China*, *8*(3), 352-360.