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# Response of Bread Wheat (*Triticum aestivum L.*) Varieties as Evaluated by Inorganic Fertilizers at Highlands of Arsi Zone

**Dereje Dobocha*, Zenebe Mulatu, Debela Bekele, Almaz Admasu, Fasil Shimeles, Wegayehu Worku**

Agronomy and Crop Physiology Program, Ethiopian Institute of Agricultural Research, Kulumsa Agricultural Research Center, Asella, Ethiopia

## Abstract

The decline in soil fertility is one of the main barriers to yield restrictions in wheat production and productivity. The experiments were carried out with the aim of evaluating the comparative advantage of NPS fertilizer over the traditional N and P fertilizer recommendations in terms of yield and yield attributes of bread wheat varieties at Lemu Bilbilo district, Oromia regional state, Ethiopia on two farm sites during 2017 main cropping season. The tests were carried out in a randomized, complete block design in a split-plot arrangement consisting of 3 bread wheat varieties (V1 = Danda'a, V2 = Digelu and V3 = Hidase) from the main plot and 4 fertilizer quantities (FR1 = recommended NP (100 kg / ha urea + 150 kg / ha DAP) (73N, 69 $P_2O_5$), FR2 = 150% RNP, FR3 = 200% RNP, FR3 = Recommended NPS (100 kg / ha) (19 N 38 $P_2O_5$ + 7S) assigned to the partial area with 3 repetitions. Results indicated the major factors varieties showed significant differences for all tested parameters in the study centers whereas fertilizers had significant effect on plant height, grain and above ground dry biological yields. Danda'a variety resulted in pick plant height, the highest grains spike$^{-1}$ (82.38), grain yield (5869.72 kg ha$^{-1}$) and above ground dry biological yield of (10.20 t ha$^{-1}$). The difference in ear length and thousand grain weight of the Danda'a variety was significantly on par with that of the Hidase variety, while the harvest index of Digelu was significantly the same with Hidase variety. Significantly higher grain and above ground dry biological yields were gained from the use of 200% RNP compared to 150% RNP, RNP and RNPS but, plant height recorded from 200% RNP was significantly at par with150% RNP. The grain and above ground dry biological yields difference among RNP and RNPS were significantly at par. Therefore, based on the study results and considering farmers cost of production 150% RNP (109.5 N and 103.5 $P_2O_5$) as 1$^{st}$ option and RNPS as the 2$^{nd}$ option were recognized and could be recommended for the production and productivity of Danda'a and Hidase bread wheat varieties in study sites and similar agroecologies.

## Keywords

Bread Wheat, Fertilizers, Yield, Varieties

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## 1. Introduction

Wheat (*Triticum aestivum L.*) is one of the main types of grain grown in most of Ethiopia [1]. It contributes to the largest part of daily consumption and source of money; contributing to 46% of GDP, over 90% of exports and 83% of job opportunities [2]. Wheat is one of the most important types of grain in Ethiopia in terms of area and production technology. It is mainly grown by subsistence farmers under rain-field conditions and ranks 4$^{th}$ after teff, maize and sorghum [3]. Most of the farming households are involved in the annual wheat production, which, however, cannot yet

* Corresponding author
E-mail address: derejegoda@gmail.com (D. Dobocha)

meet the country's annual domestic needs. According to the US Department of Agriculture's annual grain and feed report [4], wheat self-sufficiency in Ethiopia is only 75% and the remaining 25% of wheat must be imported commercially and through food aid. Therefore, a large amount of wheat is imported every year to meet increasing domestic consumer demand. Soil chemical degradation such as (soil acidity, salinity and sodity, low fertilizer content), pesticides and improved cultivars, moisture stress, are some of the main restrictions on crop production in Ethiopia [5]. Changes in soil fertility have long-term effects on productivity, but it is important to remember that changes in agriculture tend to be incremental rather than spectacular. As a result, many people suffered from food insecurity and related health problems due to malnutrition [6]. In Ethiopia, N and P are the main nutrients that limit the growth and yield of wheat. Most fertilization studies on bread wheat have been carried out with NP fertilizers. As a result, there is still a nutrient imbalance in all Ethiopian regions, as well as poor nutrient management and yield quality [7]. Nutrient degradation due to suboptimal fertilizer use coupled with agronomically imbalanced fertilizer use has favored the occurrence of multinutrient deficiencies in Ethiopian soils, which in part explains the decline in fertilizer productivity and stagnant plant productivity conditions that occur despite continued use of the blanket recommendation [8]. Acquired soil inventory data so far also revealed that in addition to nitrogen and phosphorus, sulfur, boron and zinc deficiencies are widespread in Ethiopian soils, while some soils are also deficient in potassium, copper, manganese and iron, which all potentially hold back crop productivity despite continued use of N and P fertilizer as per the blanket recommendation [9]. Balanced fertilizers containing N, P, K, S, B and Zn in mixed form have recommended alleviating site-specific nutrient deficiencies and thereby increasing land, water and labor productivity. The need for site-specific fertilizer regulations is becoming increasingly clear, but fertilization experiments with multi-nutrient mixtures containing micronutrients are rare in the Ethiopian context, including the test areas. In order to alleviate the soil fertility problem in the country including the study area, the Agricultural Transformation Agency (ATA) proposed that 100 kg $ha^{-1}$ NPS (19 N 38 $P_2O_5$ + 7S) could largely replace DAP, and has this as a blanket recommendation for nationwide introduced the country. While there is a general belief that the new fertilizer blends are better than the traditional fertilizer recommendations (urea and DAP), their comparative advantages have not been explicitly studied and understood under different production environments. However, productivity could be increased through the use of improved varieties, use of optimum inputs and better management options. Improved technologies could be evaluated and demonstrated for large scale popularization and dissemination to subsistence farmers. The use of suitable fertilizers that contain important plant nutrients such as N and P will help increase plant production and productivity. Therefore, the aim of this study was to evaluate NPS compound fertilizers in terms of yield and yield attributes of bread wheat varieties and to quantify the comparative advantage over the traditional fertilizer recommendation.

# 2. Materials and Methods

## 2.1. Description of the Study Areas

Field experiments were conducted at Lemu Bilbilo district, Oromia regional state, Ethiopia on two farm sites during 2017 main cropping season. Lemu Bilbilo district is located 235 km away from Addis Ababa to Southeast direction. The geographical location of the experimental field is at 07° 34' 87"-07° 36' 91"N and 39° 14' 44"-39° 14' 58"E, and situated at altitudes of 2591-2683 m above sea level. The average mean minimum and maximum temperatures are 7.9 and 18.6°C, respectively. It receives mean annual rainfall of 1020 mm with pseudo bi- modal distribution and maximum (2002mm) occurs in August (KARC, unpublished). Wheat, malt and food barley, faba bean and field pea are the most common crops cultivated in study site. Nitosols dominated the soil of the experimental areas [10] and silty clay in texture [11].

## 2.2. Experimental Design and Procedure

The experiments were laid out in a randomized complete block design in split plot arrangement consisting of 3 bread wheat varieties (V1 = Danda'a, V2 = Digelu and V3 = Hidase) assigned to main plot and 4 fertilizer rates (FR1 = Recommended NP (100 kg/ha Urea + 150 kg/ha DAP) (73N, 69 $P_2O_5$), FR2 = 150% RNP, FR3 = 200% RNP, FR3 = Recommended NPS (100 kg/ha) (19 N – 38 $P_2O_5$ +7S) assigned to subplot with 3 replications. Urea (46% N) 100 kg $ha^{-1}$ was used as source of N in split form of application (1/3 at planting and 2/3 at tillering) as top dress. Basal application of DAP and NPS were used at the time of planting to all experimental units. The growth size of the subplot was 4m×2.6m and net harvestable plot size of 2.4m×2.6m (6.24$m^2$). The distance between subplot and blocks (rep) were 0.5m and 1.5m, respectively. All the three tested bread wheat varieties were sown by the seed rate of 125 kg $ha^{-1}$ with 20cm inter row spacing. Other agronomic practices were properly carried out as per the recommendations of the areas.

## 2.3. Data Collected

Agronomic parameters collected included plant height(cm), spike length(cm), Grains $spike^{-1}$, grain yield( kg $ha^{-1}$),

Thousand grain weight (g), Biological yield (kg $ha^{-1}$) and Harvest index (%) which is calculated by the ratio of grain yield to biological yield. To estimate the grain yield, the net plot sizes of 2.4m×2.6m (6.24$m^2$) were harvested from each plot in December. After threshing, the harvested materials (grains) were cleaned, weighed and adjusted to 12.5% moisture level. The total grain yields recorded on a plot basis were converted to kg $ha^{-1}$ for statistical analysis.

### 2.4. Statistical Analysis

The crop data were subjected to analysis of variance using the General Linear Model procedure of R computer software version 3.6.1 [12]. The recorded data were combined over sites and analyzed. Whenever treatment effects were significant, the mean differences were separated using the Least Significant Difference (LSD) test at 5% level of significance.

**Table 1.** Fertilizer treatments used and their nutrient contents for the experiments.

| Fertilizer rates | N | $P_2O_5$ | S |
|---|---|---|---|
| FR1=RNP (100 kg/ha urea + 150 kg/ha DAP) | 73 | 69 | 0 |
| FR2=150% RNP (150 kg/ha urea + 225 kg/ha DAP) | 109.5 | 103.5 | 0 |
| FR3=200% RNP (200 kg/ha urea + 300 kg/ha DAP) | 146 | 138 | 0 |
| FR4=RNPS (100 kg/ha) | 19 | 38 | 7 |

RNP= Recommended Nitrogen and Phosphorus; RNPS=Recommended Nitrogen, Phosphorus and Sulfur

## 3. Results and Discussion

*Plant height*

Analysis of variance showed that plant height was significantly ($p < 0.05$) influenced by cultivars and fertilizers, but the interaction of cultivars and fertilizers did not show any significant. The results showed that the tallest plant height was measured by the Dandaa variety and had a significant difference between the remaining Digelu and Hidase varieties, but the Digelu and Hidase plant heights were significantly the same (Figure 1). On the other hand, the height of the pimple plants of 200% RNP was recorded and showed no significant difference between 150% RNP, but a significant difference between the residual fertilizer rates of RNP and RNPS (Figure 2). The result agreed with the results of [13], who reported that the plant height of the culture is mainly controlled by the genetic makeup of a genotype and can also be influenced by environmental factors. These results showed that the height of the plants increased as the amount of fertilizer increased. This increase in plant height could be due to the role nitrogen plays in cell wall formation, which contributed to increased plant height. These results were consistent with the work of [14] who stated that the increase in plant height was associated with the addition of nitrogen.

*Spike length*

A result of this study on the ear length is shown in Table 2. The analysis of variance showed that only the main effect of the variety had a significant effect on the ear length of bread wheat, while the main effects of fertilizers and the interaction between varieties and fertilizers over the length of the spike were not significant. The results showed that the maximum ear length (8.39 cm) of the cultivar Danda'a was found and was not significant with the ear length (7.98 cm) of the cultivar Hidase. Significantly, however, the minimum ear length (7.02 cm) of the Digelu variety was found. Thus, it can be concluded from these results that the peak length is a genetic characteristic of a variety. This result was compatible with those of [15] who observed that individual genotypes reacted differently to the length of the ears of different wheat varieties. Previous studies have shown that varieties have different genetic potentials in terms of ear length [16].

*Grains $spike^{-1}$*

The analysis of variance showed significant ($p < 0.05$) effects for the factor varieties for grains $spike^{-1}$, while the influence of fertilizers and the interaction of varieties and plant densities were not observed for the character number of the grains $spike^{-1}$. The maximum number of grains Spike-1 (82.38) was recorded from the cultivar Danda'a and was found to be significant in the cultivar Hidase, but the difference between the cultivar Digelu was statistically the same (Table 1). The results so far have shown that the grain number and grain weight of wheat are influenced by both genetic and environmental factors [17].

*Grain yield*

The results of the analysis of variance showed that the main factor effects of cultivars and fertilizers were significant ($p < 0.05$) on grain yield, but the interactions of cultivars and fertilizers were not significant. Statistics indicated that there were significant differences between the grain yields of the Danda'a, Digelu, and Hidase varieties, but the maximum and minimum grain yields were achieved by the Danda'a and Digelu varieties, respectively (Figure 3). On the other hand, the grain yield rose to its peak at 200% RNP, which was well above 150% RNP, RNP and RNPS. In addition, there were significant differences between the yield of 150% RNP and RNPS, but the yield difference between RNP and 150% RNPS was statistically the same (Figure 4). Wheat varieties produce

different yields at the trial sites, which could be due to the combined effect of N and P nutrients, which may have promoted the growth and development of the crops [18]. These results are confirmed by the results of [19], who reported that increasing nitrogen fertilization increased the grain yield of wheat. Similarly [20] reported that the application of nutrients such as K, S, Zn, Mg and B significantly increased the grain yield and the yield component of bread wheat compared to unfertilized plots.

*Above ground dry biological yield*

The main cultivar and fertilizer factors influenced significantly ($P < 0.05$) the aboveground dry biological yield of bread wheat, while their interactions were not significant. A significantly higher mean biological yield was obtained from the cultivar Danda'a, whereas; lower mean biological yield was obtained from the Digelu variety (Figure 5). This result agreed with the results of [21] and [22], which stated that the biological yield is significantly influenced by wheat varieties. The increased biomass production in the Danda'a variety could be attributed to the maximum plant height, and ear length recorded by the variety. The present result agrees with the findings of [23], which showed a positive relationship between biomass yield and plant height. With regard to fertilizers, the highest above-ground dry biological yield measured by 200% RNP was found to be significantly different from the rest of the fertilizer rates, but the differences in above-ground dry biological yield measured by 150% RNP, RNP and RNPS were significantly at par (Figure 6). The results are in agreement with the results of [24] who found that macro and micronutrients play an important role in plant nutrition and are therefore important for achieving higher yields, better growth and better development of plants.

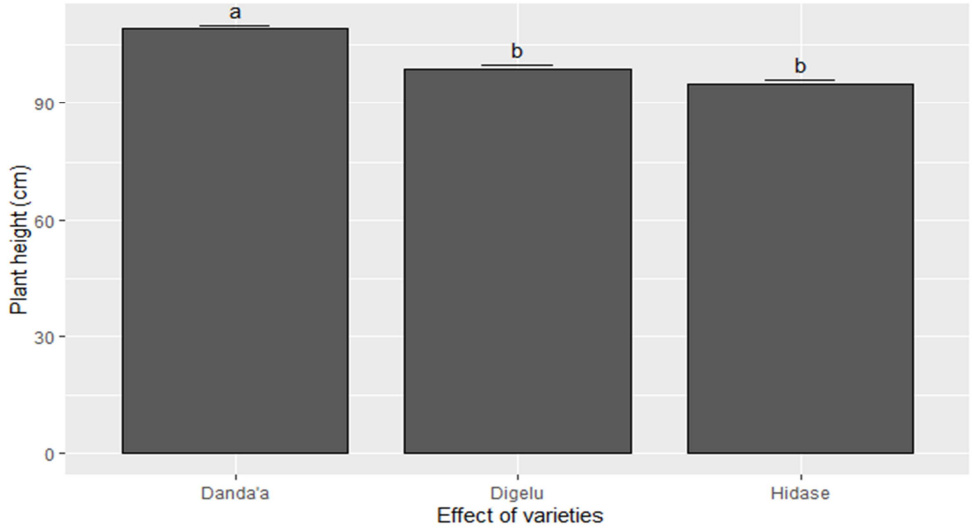


**Figure 1.** Effect of varieties on plant height of bread wheat averaged over sites.


**Figure 2.** Effect of fertilizers on plant height of bread wheat averaged over sites.

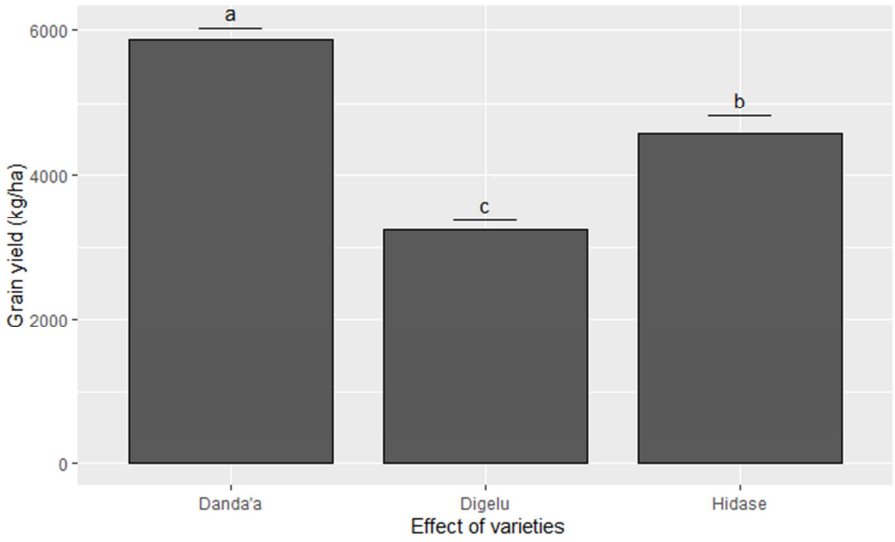


**Figure 3.** Effect of varieties on grain yield of bread wheat averaged over sites.

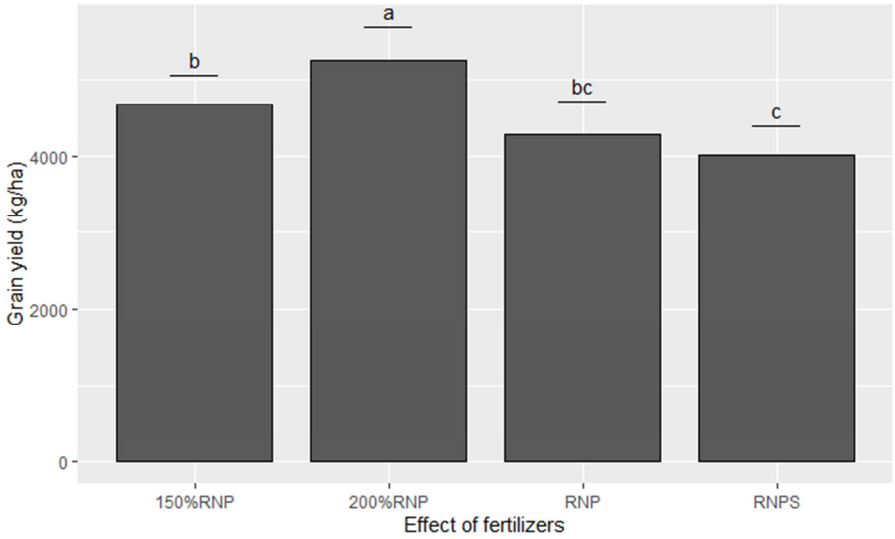


**Figure 4.** Effect of fertilizers on grain yield of bread wheat averaged over sites.

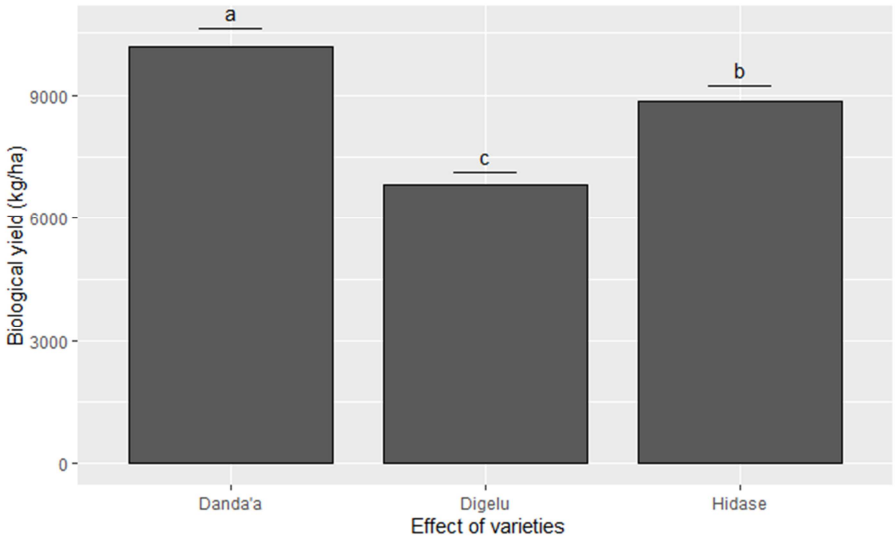


**Figure 5.** Effect of varieties on biological yield of bread wheat averaged over sites.

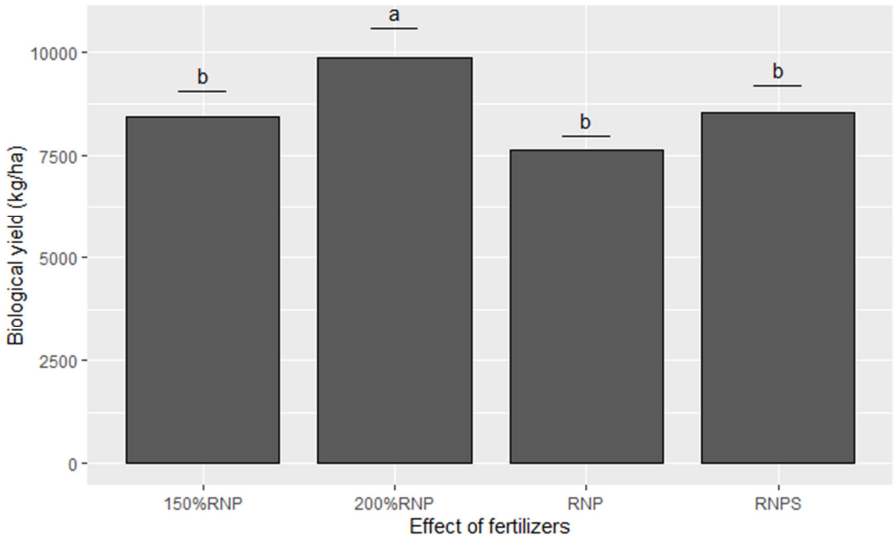


**Figure 6.** Effect of fertilizers on biological yield of bread wheat averaged over sites.

*Harvest index*

The result of the harvest index is shown in Table 2. The harvest index was significantly (P <0.05) influenced by the main factor of the varieties and not significantly influenced by the fertilizer quantities plus the interaction effect of fertilizers and varieties. A significantly higher mean harvest index of (44.32%) was obtained from the Danda'a variety. The harvest index (39.95%) of the Digelu variety was statistically the same as the harvest index (41.97%) of the Hidase variety. The result was in agreement with the results of [25], which stated that the higher the harvest index value, the greater the physiological potential of the culture to convert dry matter into grain yield. Consistent with this study result [26], it was found that a variety's ability to convert dry matter into an economic yield is indicated by its harvest index. The harvest index had a correlation with the grain yield and the aboveground biomass yield in that the highest harvest index was the result of a higher grain yield and the lowest harvest index was mainly due to a higher plant height, which increased the biomass yield extremely, and not to the grain yield which led to a decrease in harvest led index [26].

**Table 2.** The effects of varieties and fertilizers on spike length, grain per spike, 1000-grain weight and harvest index of bread wheat averaged over sites.

| Treatments | Spike length(cm) | Grain spike$^{-1}$ | 1000-grain weight(g) | Harvest index (%) |
|---|---|---|---|---|
| Varieties | | | | |
| Danda'a | 8.39a | 82.38a | 48.58a | 44.32a |
| Digelu | 7.02b | 79.03a | 39.26b | 39.95b |
| Hidase | 7.98ab | 72.16b | 50.35a | 41.97b |
| LSD (5%) | 1.04 | 6.00 | 3.80 | 2.10 |
| CV (%) | 8.20 | 4.80 | 5.10 | 3.10 |
| Fertilizers | | | | |
| RNP | 7.66 | 76.32 | 46.05 | 42.78 |
| 150%RNP | 7.83 | 78.40 | 46.16 | 41.32 |
| 200%RNP | 7.92 | 77.466 | 46.51 | 41.30 |
| RNPS | 7.77 | 79.255 | 45.52 | 42.91 |
| LSD (5%) | NS | NS | NS | NS |
| CV (%) | 4.8 | 3.4 | 3.2 | 4.60 |

Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of significance, NS: Not significant

Thousand kernels weight

The thousand kernels weight (TKW) was significantly (P<0.05) influenced by the main factor varieties and not significantly (P<0.05) influenced by fertilizers and the interactions between varieties and fertilizers. The tank trucks of the Hidase (50.35 g) and Danda'a (48.58 g) varieties were significantly higher than those of the Digelu (39.26 g) variety and showed no significant values among each other (Table 2). The result agreed with the findings of [25] that the reported TKW is a quality parameter for assessing the grain quality of wheat and is influenced by the genetic makeup of varieties.

## 4. Conclusion

The results showed that the use of different varieties showed significant differences in all parameters in the study, while fertilizers had a significant impact on some of the parameters used, with the exception of the spike length, grains spike$^{-1}$,

harvest index and thousand kernels weight (TKW), which have not been significantly affected by fertilizers. The interaction of varieties and fertilizers showed no significant difference in any of the parameters examined in experiments. The Danda'a variety resulted in pick plant height, the highest grain yield, above ground dry biological yield and harvest index whereas; its spike length and TKW were significantly comparable to that of the Hidase variety. Based on the present study, significantly higher grain and above ground dry biological yields were achieved when using 200% RNP compared to 150% RNP, RNP and RNPS , but the measured plant height of 200% RNP was significantly the level of 150% RNP. The difference between cereals and above-ground dry biological yields between RNP and RNPS was significantly the same. Therefore, on the basis of the study results and taking into account the farmers' production costs, 150% RNP (109.5 N and 103.5 $P_2O_5$) were recognized as the 1st option and RNPS as the 2nd option and can be used for the production and productivity of the bread wheat varieties Danda'a and Hidase are recommended at test sites and similar agroecologies.

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