

# Nitrogen fertilization effects on grain quality of durum wheat (*Triticum turgidum* L. var. durum) varieties in central Ethiopia

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## ABSTRACT

Four released durum wheat varieties, two medium tall (Arsi-Robe and Kilinto) and two recently released semi-dwarfs (Ude and Yerer) were evaluated under five different N rates (0, 60, 120, 180 and 240 kg·ha<sup>-1</sup>) in 2005/06 growing season at Akaki and Debre Zeit, central Ethiopia. The quality responses of durum wheat varieties to different N-fertilizer rates and the N responses between tall and short durum wheat varieties were assessed. Protein and gluten content, vitreous kernel count, thousand kernel weight, test weight and lodging were considered. Vitreous kernel count, protein and gluten content were higher at Debre Zeit than at Akaki. Unlike Debre Zeit, there were significant relationships between response variables and fertilizer levels at Akaki. Lodging slightly affected the medium tall varieties at Debre Zeit whereas it was not a problem at Akaki. At Akaki, varieties response to each additional N rate was entirely below the quality standard set by ICC, 2000 except for thousand-kernel weight. Therefore, it is unwise to promote durum wheat scaling up/out program for quality production at Akaki.

**Keywords:** Gluten Content; N-Fertilization; Protein Content; Thousand Kernel Weight; Test Weight; Vitreous Kernel Count

## 1. INTRODUCTION

Durum wheat (*Triticum turgidum* L. var. durum) is the second most important wheat species grown in the world next to bread wheat (*Triticum aestivum* L.). It is the best wheat for pasta products due to its strong gluten, excel-

lent amber color and superior cooking quality [1,2]. It has been cultivated in Ethiopia for thousands of years. However, it has been gradually replaced by bread wheat. Currently, the growing demand for pasta is enhancing durum wheat production. Low volumes and poor quality of the national wheat production compels Ethiopia pasta industries to import the required raw material [3]. As a result, the pasta factories annually import about 0.2 million tons of durum wheat.

The quality of durum wheat is highly dependent on the protein content of the grain, which is largely dependent on genotypes and influenced by environment, especially nitrogen (N) availability of the soil [4]. Nitrogen fertilization management therefore offers the opportunity for increasing wheat protein content and other related quality traits. According to Motzo *et al.* (2004) grain protein content is a function of total nitrogen uptake and of the partitioning of nitrogen and dry matter to the grain [5]. Franzen and Goos (1997) also indicated that protein content consistently lower than 12% or starch content “yellow bean” kernels higher than 20% is an indication that a wheat producer needs to use more N fertilizer or better manage the N being applied [6].

In Ethiopia, durum wheat is mainly grown on heavy black clay soils (Vertisols) of highlands with altitude range of 1800 to 2800 m asl exclusively under rain fed conditions [7]. Vertisols in Ethiopia and other part of Africa generally have soil pH ranging between 7.5 - 8.5 in the soil profile [8]. This high pH content of the Vertisols favors gaseous loss of ammonia when urea or ammonium fertilizers are applied to the surface [9,10]. As a result, durum wheat is mostly successful in soils with pH 6 in CaCl<sub>2</sub> [11]. On the other hand, the low infiltration rates of vertisols could also create environment favorable for denitrification since O<sub>2</sub> diffusion rate in water is very low [12,13]. Geleto *et al.* (1996) also reported that nitrogen deficiency is a common problem in cool, wet areas,

such as in highland Vertisols [14]. Therefore, in addition to draining the soil, nitrogen fertilization of durum wheat is very important to mitigate the risk of N losses and to improve the quality of grain.

In the past, although Ethiopia is the largest producer in sub-Saharan Africa, little emphasis was given on improving the quality of durum wheat. Currently, the national research institutes and pasta processing industries are jointly working to improving durum wheat grain quality. Increasing domestic quality produce could mitigate not only the shortage but also substitutes the import of huge industrial raw materials. It also enables resource poor farmers fetch premium price. Therefore, it is vital to study soil fertility management practices across locations so as to improve the quality and market demand for the crop.

Bemnet *et al.* (2003) studied the effects of up to 120 kg·N·ha<sup>-1</sup> on durum wheat quality using five medium-tall to tall varieties at Debre Zeit and Akaki [15]. Their results indicated that it is possible to grow quality durum wheat for the local industries at both locations, except vitreous kernel count (VKC) that was lower than the acceptable quality (80%) at Akaki. Thus in areas like Akaki, a higher level of N has to be applied to produce quality seeds with high VKC [16]. On the other hand, higher levels of N may induce lodging on medium-tall varieties, in which case the possibility of growing semi-dwarf types were investigated.

The semi-dwarf durum wheat varieties, Ude and Yerer were released in 2002 and are currently under production. Both have high quality traits for pasta making and are relatively early maturing. The other two medium-tall varieties Arsi-Robe and Kilinto were respectively released in 1996 and 1994. Both are currently under production. Arsi-Robe is renowned for its higher protein content over Kilinto. However, Kilinto does grow well under wide ranges of rainfall (400 - 1200 mm/annum) [17]. Even though, they all have respective similarities with in their group, the semi-dwarf varieties have very close physical and quality attributes over the semi-tall varieties.

## Objectives

- 1) To assess the quality responses of durum wheat varieties to different N-fertilizer rates;
- 2) To compare the N responses between tall and short durum wheat varieties.

## 2. MATERIALS AND METHODS

### 2.1. The Study Area

The experiment was conducted at Debre Zeit research station and Akaki substation (**Figure 1**), in the 2005/06 main growing seasons. Debre Zeit Agricultural Research Center is located 50 km to the southeast of Addis Ababa (8°44'N, 39°02'E) in mid-highland (1900 m asl), and is

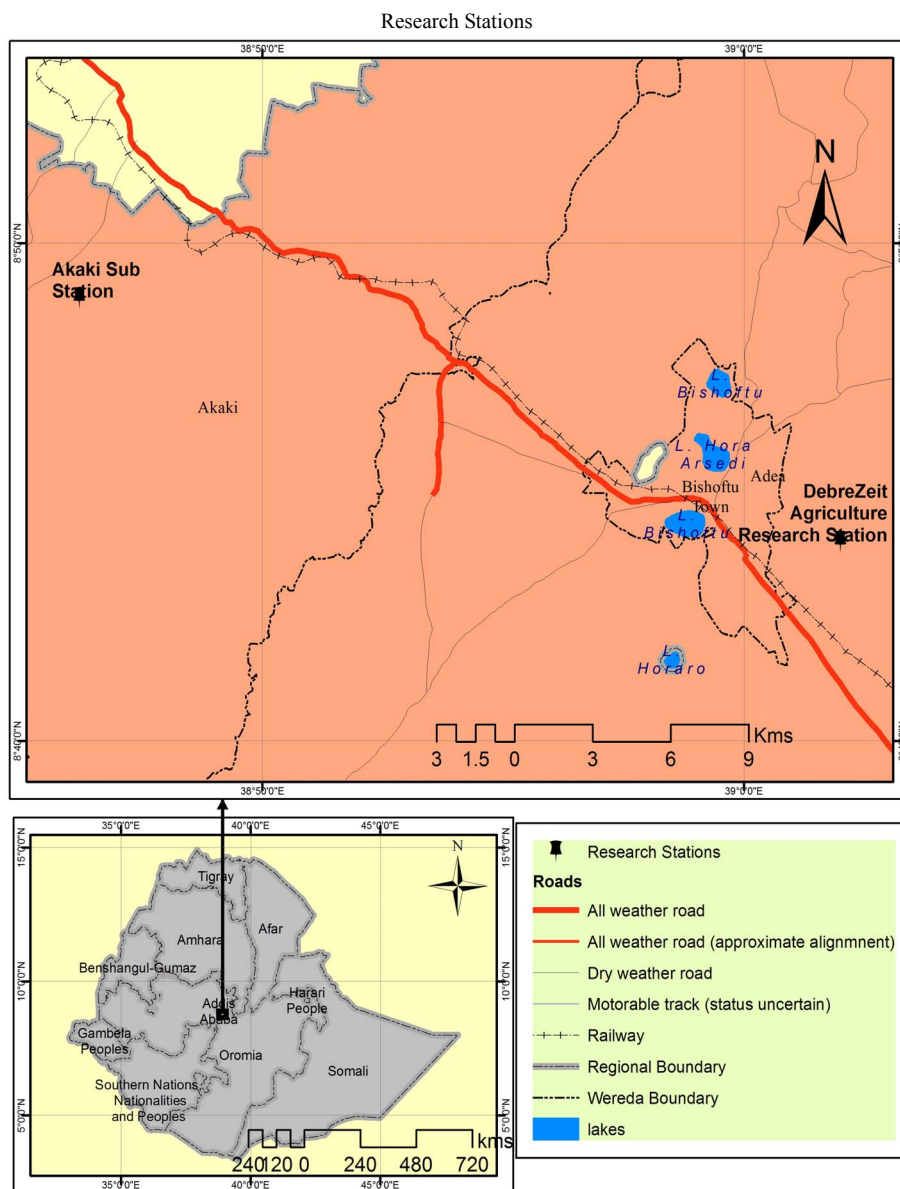
characterized by 851 mm mean annual rainfall and mean temperature of about 18°C ([3]. Akaki substation is located 27 km to the south east of Addis Ababa (08°54'N 38°45'E) in the highland area (2200 m asl) and is characterized by 1025 mm mean annual rainfall and about 17°C mean annual temperature (**Figure 1**). Mean monthly rainfall and temperature of the growing season for both sites is presented in **Table 1**. At both locations, pellic Vertisols are the major soil type.

### 2.2. Treatments and Experimental Design

Four released durum wheat varieties; two medium-tall (Arsi-Robe and Kilinto) and two recently released semi-dwarfs (Ude and Yerer), were evaluated under five Nitrogen (N) rates (0, 60, 120, 180 and 240 kg·ha<sup>-1</sup>) with uniform basal application of 20 kg·P·ha<sup>-1</sup>. The treatments were factorially combined and arranged in a Randomized Complete Block Design (RCBD) with three replications (**Table 2**). The area of the experimental field is 737 m<sup>2</sup>. The plot size was 7.2 m<sup>2</sup> and the space between each plot is 0.5 m. Generally, 60 plots arranged in 3 blocks with 2 meter path between each block. Each plot had a total of six planting rows having 0.2 m intervals. Data were recorded from the four central rows of each plot. Seeding rate of 150 kg·ha<sup>-1</sup> was used. Seeds were drilled by hand in the rows drawn using a manual row marker. Sowing dates were on 12 July 2005 for Akaki and on 21 July 2005 for Debre Zeit. Broad Bed and Furrows (BBF) was used to facilitate surface drainage of the Vertisols [18]. Split application of N fertilizer at sowing (50%, except the control) and the remaining at the end of tillering has been done to reduce the risk of loss by applying a single, high nitrogen early in the season ([19,20]. Post-emergence weed control was by hand weeding. Harvesting dates were 19-20 November for Debre Zeit and 24-25 November for Akaki.

### 2.3. Data Collection and Analysis

Composite topsoil samples (0 - 30 cm) from both locations were randomly taken from representative areas using augur. The percent organic matter and organic carbon of the sampled soils was determined using the wet oxidation method [21,22]. Total nitrogen (N) was determined by the Kjeldhal method [23-25]. Available phosphorus (P) was determined by the Olsen method [26]. Soil pH was measured potentiometrically in the supernatant suspension of a 1:1 liquid mixture using pH meter in water (pH-H<sub>2</sub>O) [27]. Lodging was recorded according to lodging index [28]. About 250 g seed samples from 120 plots each over two locations were taken after threshing for analysis. Each sample was ground, sieved and analyzed for total nitrogen content. Whole mill nitrogen (N) contents were determined using macro Kjel-



**Figure 1.** Location of the study sites (Debre Zeit and Akaki).

**Table 1.** Mean rainfall (mm) and temperature (°C) of Debre Zeit and Akaki during the growing season.

Location	Year	Monthly rainfall (mm)					Temperature (°C)			
		June	July	August	September	Σ	June	July	August	September
Akaki	Previous year	122.2	232.5	211.9	92.1	658.7	20.7	19.4	19.5	20.0
	2005/6	139.9	234.8	231.0	149.7	755.4	20.9	19.5	20.1	20.3
D/Zeit	Previous year	98.9	234.6	213.1	72.3	618.9	20.0	19.0	18.8	18.5
	2005/6	103.3	179.9	138.2	129.3	550.7	19.1	18.4	18.9	18.6

dahl-method. The analysis was made in the Soil and Water Research Laboratory at Debre Zeit Agricultural Research Center (DZARC).

Gluten content was determined at Kality Food Share Company by taking 10 gm of endosperm flour and the dough was prepared from the flour and 5 ml of 2% So-

**Table 2.** Arrangements of experimental treatments.

B <sub>1</sub>	V <sub>1</sub> F <sub>5</sub>	V <sub>3</sub> F <sub>5</sub>	V <sub>1</sub> F <sub>1</sub>	V <sub>3</sub> F <sub>4</sub>	V <sub>2</sub> F <sub>3</sub>	V <sub>2</sub> F <sub>4</sub>	V <sub>4</sub> F <sub>4</sub>	V <sub>1</sub> F <sub>4</sub>	V <sub>2</sub> F <sub>2</sub>	V <sub>2</sub> F <sub>1</sub>	V <sub>2</sub> F <sub>5</sub>	V <sub>4</sub> F <sub>5</sub>	V <sub>4</sub> F <sub>3</sub>	V <sub>3</sub> F <sub>1</sub>	V <sub>3</sub> F <sub>3</sub>	V <sub>4</sub> F <sub>2</sub>	V <sub>4</sub> F <sub>1</sub>	V <sub>4</sub> F <sub>2</sub>	V <sub>1</sub> F <sub>2</sub>	V <sub>3</sub> F <sub>3</sub>
B <sub>2</sub>	V <sub>3</sub> F <sub>2</sub>	V <sub>3</sub> F <sub>4</sub>	V <sub>3</sub> F <sub>3</sub>	V <sub>2</sub> F <sub>3</sub>	V <sub>2</sub> F <sub>2</sub>	V <sub>3</sub> F <sub>1</sub>	V <sub>4</sub> F <sub>3</sub>	V <sub>3</sub> F <sub>5</sub>	V <sub>4</sub> F <sub>2</sub>	V <sub>2</sub> F <sub>4</sub>	V <sub>1</sub> F <sub>1</sub>	V <sub>4</sub> F <sub>1</sub>	V <sub>1</sub> F <sub>2</sub>	V <sub>1</sub> F <sub>4</sub>	V <sub>1</sub> F <sub>5</sub>	V <sub>4</sub> F <sub>4</sub>	V <sub>1</sub> F <sub>3</sub>	V <sub>4</sub> F <sub>5</sub>	V <sub>2</sub> F <sub>5</sub>	V <sub>2</sub> F <sub>1</sub>
B <sub>3</sub>	V <sub>2</sub> F <sub>1</sub>	V <sub>4</sub> F <sub>4</sub>	V <sub>4</sub> F <sub>2</sub>	V <sub>4</sub> F <sub>3</sub>	V <sub>4</sub> F <sub>5</sub>	V <sub>1</sub> F <sub>3</sub>	V <sub>1</sub> F <sub>4</sub>	V <sub>2</sub> F <sub>4</sub>	V <sub>2</sub> F <sub>2</sub>	V <sub>4</sub> F <sub>1</sub>	V <sub>2</sub> F <sub>3</sub>	V <sub>1</sub> F <sub>1</sub>	V <sub>3</sub> F <sub>2</sub>	V <sub>1</sub> F <sub>5</sub>	V <sub>2</sub> F <sub>5</sub>	V <sub>3</sub> F <sub>1</sub>	V <sub>3</sub> F <sub>3</sub>	V <sub>1</sub> F <sub>2</sub>	V <sub>3</sub> F <sub>5</sub>	V <sub>1</sub> F <sub>4</sub>

B<sub>1</sub> = block 1, B<sub>2</sub> = block 2, B<sub>3</sub> = block 3; V<sub>1</sub> = Arsi-Robe, V<sub>2</sub> = Kilinto, V<sub>3</sub> = Ude, V<sub>4</sub> = Yerer; F<sub>1</sub> = Zero fertilizer, F<sub>2</sub> = 60 kg·N, F<sub>3</sub> = 120 kg·N, F<sub>4</sub> = 180 kg·N, F<sub>5</sub> = 240 kg·N.

dium Chloride solutions. The dough ball was made for eight minutes [29] and then by washing away the starch using the sodium chloride solution, the wet gluten was isolated from the starch and other soluble materials. The washed away dough was frequently pressed in the middle of dough presser to reduce the moisture content of the dough ball. Ultimately, converted percentage weight of the wet gluten was recorded.

Eventually, grain protein, vitreous kernels count, test weight, thousand-kernel weight and wet gluten data were collected. The data was subjected to Analysis of Variance using SAS statistical software [30]. A regression analysis to examine the relationship between dependent variables and the independent variable was done.

### 3. RESULTS AND DISCUSSION

Due to heterogeneity of data over location, combined analysis of protein content was not done. Quality response of durum wheat varieties at two locations were independently evaluated for their industrial quality. At Debre Zeit, grain analysis gave slightly higher protein content than Akaki (Table 3). This could be attributed to the higher nitrogen in the soil left over from the previous season (Table 4) and the warmer weather condition at Debre Zeit. In contrast to the findings of Ames *et al.* (2003) and Metho *et al.* (1997) additional nitrogen fertilization did not significantly increase grain protein content of the varieties at both locations (Table 3) [31, 32].

ANOVA at Debre Zeit showed that there were no significant differences in protein content among N rates and fertilizer x varieties interaction, but there was significant ( $P < 0.05$ ) difference among varieties (Table 5). The two semi dwarf varieties Ude and Yerer gave high protein yield, comparing to the other two medium tall varieties (Table 6). Contrary to the findings of Bemnet *et al.* (2003), Arsi-Robe had the lowest protein content that could be attributed to lodging of the variety right after heading.

At Akaki, the effect of N rates on protein content was not significant ( $P < 0.05$ ). There was also no significant difference among varieties, and varieties x fertilizer interaction (Table 5). This study agrees to Bemnet *et al.* (2003) at Akaki. The relatively lower but acceptable

grain protein content may be partially attributed to the high rainfall that might have resulted in N loss notably through gaseous/denitrification, leaching, and lower temperature of the area. Abaye *et al.* (1997) reported that drier and/or warmer condition during the growing season enhances the accumulation of higher grain protein. According to Simmonds (1989) starch production is favored rather than protein under high rainfall and low soil fertility conditions [33]. This could also lead to dilution, and hence low protein content.

Bemnet *et al.* (2003) and Campbell *et al.* (1993) reported that most grain quality traits in wheat, including protein content are affected by genetic and environmental factors. During crop maturity period, however, chilly and windy weather prevailed at both locations with condition at Akaki being chiller than that of Debre Zeit. According to Srivastava (1984), durum wheat is susceptible to low temperature and severe frost [34].

At Debre Zeit, all varieties gave substantial proportion of vitreous kernel counts. There was no significant ( $P < 0.05$ ) difference among varieties, fertilizer, and varieties × fertilizer interaction (Table 5). The highest mean vitreous kernel count (99.2%) showed that at Debre Zeit it is possible to produce high quality durum wheat. Similar kernel vitreousness among all varieties at Debre Zeit might be attributed to the relatively low rainfall, warmer condition and the carry over (residual) effects of nutrient in the soil (Tables 1 and 4). Bemnet *et al.* (2003) also reported that Debre Zeit has favorable condition for kernel vitreousness.

At Akaki kernel vitreousness was very poor compared to equal N rate at Debre Zeit (Table 3). Mean vitreous kernel count at Akaki was extremely below the standard in which case variety Kilinto was remarkably inferior to all other varieties (Table 6). The high rainfall that prevailed during the growing season might have attributed to lower vitreousness. According to Simmonds (1989), starch production is favored rather than vitreous kernel count under high rainfall and lower soil fertility conditions. In general, kernel vitreousness response of varieties to N rates at Akaki was very poor except for varieties Arsi-Robe and Yerer at 180 and 240 kg·N·ha<sup>-1</sup>, respectively.

Wet gluten was determined according to ICC, 2000. At

**Table 3.** Effect of N rates on mean values of quality traits of durum wheat varieties grown at Debre Zeit and Akaki in 2005.

N rates (kg·ha <sup>-1</sup> )	Debre Zeit					Akaki				
	GP (%)	VKC (%)	WG (%)	TKW (g)	TW (kg·hl <sup>-1</sup> )	GP (%)	VKC (%)	WG (%)	TKW (g)	TW (kg·hl <sup>-1</sup> )
0	14.9	97.3	41.0	33.2	75.9	14.3	43.3	24.9	36.1	78.2
60	15.9	99.2	49.9	31.0	75.2	12.1	21.8	23.0	39.3	77.7
120	16.6	99.8	51.4	29.4	73.7	13.1	50.4	27.0	41.1	79.0
180	16.0	99.8	53.3	29.3	73.7	13.1	71.5	32.5	44.3	79.0
240	16.2	99.9	54.5	29.4	73.8	14.9	75.7	34.0	46.0	78.0
Mean	15.9	99.2	50.0	30.4	74.5	13.5	52.6	28.3	41.3	78.4
LSD (0.05)	NS	NS	3.9	1.1	0.9	NS	9.7	2.2	1.70	NS

GP = grain protein; VKC = vitreous kernel count; WG = wet gluten; TKW = thousand kernel weight; TW (kg·hl<sup>-1</sup>) = test weight kg/hectoliter; NS = not significant.

**Table 4.** Pre-treatment soil characteristics of the study area.

Location	Year	Soil characteristics					
		pH	OM (%)	OC (%)	N (%)	C/N	P (ppm)
D/Zeit	2005/6	6.47	1.02	0.59	0.170	3.5	22.6
Akaki	2005/6	6.37	0.76	0.44	0.045	9.8	4.9

pH = measure of acidity/alkalinity; OM = organic matter; OC = organic carbon; N = available nitrogen; P = available phosphorus.

**Table 5.** Mean square of quality traits of durum wheat varieties grown at Debre Zeit and Akaki in 2005.

Sources	DF	Debre Zeit					Akaki				
		GP (%)	VKC (%)	WG (%)	TKW (g)	TW (kg·hl <sup>-1</sup> )	GP (%)	VKC (%)	WG (%)	TKW (g)	TW (kg·hl <sup>-1</sup> )
Replication	2	2.6	12.1	125.9	2.1	1.2	8.3	38.8	9.1	61.2	14.0
Variety (V)	3	12.8*	9.4	379.7**	97.9**	43.0**	6.1	4434.0**	291.0**	119.9**	10.7**
Fertilizer (F)	4	4.3	14.4	343.2**	33.5**	12.1**	14.9	5779.5**	272.0**	182.6**	3.3
V × F	12	3.3	3.1	38.8	2.1	1.4	3.8	440.0**	20.8**	19.8**	3.3
Error	38	3.5	6.0	22.6	1.7	0.9	6.5	137.3	7.2	4.0	2.0
C.V. (%)		2.5	11.7	9.5	1.3	4.2	22.0	18.9	9.5	1.8	4.9

\*\*Significant at the 0.01 and 0.05 probability level, respectively; GP = grain protein; VKC = vitreous kernel count; WG = wet gluten; TKW = thousand kernel weight; TW (kg·hl<sup>-1</sup>) = test weight kg/hectoliter.

**Table 6.** Mean values of quality traits of durum wheat varieties grown at Debre Zeit and Akaki in 2005.

Variety	Debre Zeit					Akaki				
	GP (%)	VKC (%)	WG (%)	TKW (g)	TW (kg·hl <sup>-1</sup> )	GP (%)	VKC (%)	WG (%)	TKW (g)	TW (kg·hl <sup>-1</sup> )
Arsi-Robe	14.9	99.3	51.0	33.0	76.7	13.5	62.5	32.5	37.2	78.2
Kilinto	15.3	98.1	44.8	32.1	75.0	13.2	27.1	22.3	43.6	79.0
Ude	16.8	99.7	47.8	29.2	73.1	14.4	57.3	28.0	42.3	77.4
Yerer	16.6	99.8	56.6	27.5	73.2	12.9	63.3	30.3	42.2	79.2
Mean	15.9	99.2	50.0	30.4	74.5	13.5	52.6	28.3	41.3	78.4
LSD (0.05)	1.4	NS	3.5	0.95	0.7	NS	8.7	2.0	1.5	1.0

GP = grain protein; VKC = vitreous kernel count; WG = wet gluten; TKW = thousand kernel weight; TW = test weight; NS = not significant.



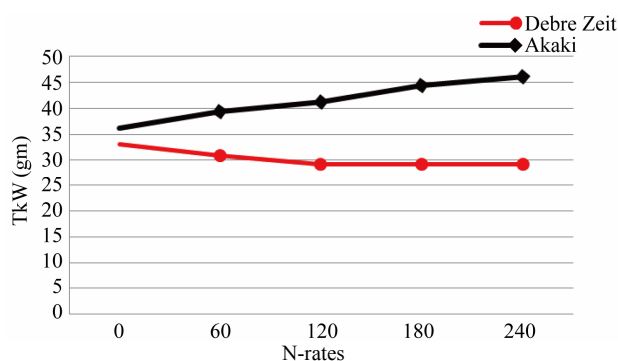
Debre Zeit, extremely high gluten content, 54.5% was recorded at  $240 \text{ kg}\cdot\text{N}\cdot\text{ha}^{-1}$  (Table 3). It is higher than any of the imported hard/or durum wheat ever recorded in Ethiopia. Hence, gluten content at all N rates was enormous compared to any of the domestic produce. It increased with increasing N rates. Although all varieties at all N rates gave acceptable wet gluten content, Yerer's result was superior to other varieties (Table 6). High mean gluten content of durum wheat varieties at Debre Zeit corroborates the suitability of the location for growing durum wheat with excellent cooking quality.

At Akaki, there were significant differences due to the main effects and the interaction for gluten content. Regardless of protein content, varietal difference was observed for all estimates of gluten strength. Gluten content increased with increasing N rates, generally. However, only the product from Arsi-Robe and Yerer met the domestic quality standards (Table 6). At both locations, the gluten content of Kilinto was inferior to all other varieties (Table 6).

At Debre Zeit, as shown in Table 3 there was a decrease in thousand-kernel weight with increasing N rate. There were significant differences among varieties and N rates. Thousand kernel weight has shown a linear relationship with N rates at both locations but with opposite trends (Figure 2). Hadjichristoudoulou (1979) reported that there was no effect of N rate on thousand kernel weight. Campbell *et al.* (1977) reported that N rate decreased thousand kernel weights or had no effect [35]. The control treatment at Debre Zeit gave a relatively higher thousand-kernel weight, but the mean thousand-kernel weight (30.4 g) was the minimum compared to the standard. In addition to increased soil N rates, it may also be attributed to the prevailed cold and windy weather condition during the grain filling period.

At Akaki, mean thousand-kernel weight (41.3 g) showed positive response to N rates. Both the main effects and the interactions were significant. It had significant linear relationship to N rate (Figure 2). At 180 and 240  $\text{kg}\cdot\text{N}\cdot\text{ha}^{-1}$  higher thousand kernel weights of 44 and 46 g, respectively, were recorded (Figure 2, Table 3). Mean thousand-kernel weight for Akaki surpassed the standard thousand-kernel weight (35 - 40 g) for pasta industry. At Akaki, Kilinto had superior thousand kernel weights followed by Ude and Yerer (Table 6). Like other quality traits, thousand-kernel weight was also location specific.

At Debre Zeit, the test weight decreased with increasing N level (Table 3). Yamazki and Briggie (1969) reported that grain shape is associated with packing efficiency while the environment where the crop is grown mostly affects kernel density [36]. Budak (2000) also confirmed that Kernel shriveling due to drought stress during grain filling period of wheat results in decreasing test weight and grain yield [37]. The prevailing weather



**Figure 2.** Relationships of thousand kernel weight to N rate at Debre Zeit and Akaki.

condition during grain filling period at Debre Zeit and Akaki corroborates this finding.

At Akaki, however, there was only significant difference among varieties (Table 5). Accordingly, Yerer provided higher test weight followed by Kilinto (Table 6). In contrast to Debre Zeit, slightly higher test weight was obtained at Akaki. In durum wheat, Troccoli and di Fonzo (1999) found a strong relationship between kernel size features and test weight [38].

At Debre Zeit, the two medium tall varieties were slightly affected by lodging. This could be attributed to residual soil N, torrential rainfall, taller stem and windy condition. Stoskopf (1985) reported that lodging could be promoted by physical force exerted by wind, rain and/or by genetically weak straw [39]. Mean lodging at Debre Zeit was 11.6%. Arsi-Robe was the tallest variety followed by Kilinto; the average lodging was higher on Arsi-Robe and Kilinto with 27.5% and 18.0%, respectively, whereas, lodging is not a problem in Akaki.

#### 4. CONCLUSION

The results of nitrogen fertilization effects on grain qualities of four released durum wheat varieties over two locations indicated that increase in the rate of applied nitrogen beyond  $120 \text{ kg}\cdot\text{N}\cdot\text{ha}^{-1}$  increased the vitreousness and wet gluten content over locations; and grain protein content, test weight and thousand-kernel weight of durum wheat at Akaki. However, quality grain was generally produced at Debre Zeit than at Akaki. Poor quality durum wheat production at Akaki may lead durum wheat farmers to shift their practices from durum to bread wheat. At this site, despite the rate of N fertilization, almost all varieties gave low quality produce in terms of vitreous kernel count and wet gluten content. In general, fertilizing at economic N rate based on site specific average yield potential and soil  $\text{NO}_3$  (N) test is highly important to obtain economical yields and quality products. Additional application of N to soil in high precipitation areas like Akaki, however, boosts only the

yield than the quality.

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