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Adaptation and Promotion of Irrigated Wheat Genotypes at Tendahoo Sugar Factory, Afar Regional State of Ethiopia

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Abstract

Six candidate wheat genotypes were tested in RCBD replicated three times following appropriate statistical procedures to evaluate adaptation ability and yield performance of the genotypes to identify the best performing genotypes under Tendaho condition. The trials were carried out using furrow irrigation for two consecutive years (2016/17 and 2017/8) following standard agronomic practices. The two years combined data was statistically analyzed using Gen Stat 15th Edition Software. The correlation coefficient of yield and adjusted yield and yield traits of tested wheat genotypes was also analyzed using SAS software. The combined years analysis of variance shown that the tested genotypes differed significantly ($p<0.05$) with respect to their date of heading (DH), date of maturity (DM), Plant height (PLH), Spike length (SPL), number of spikelet per spike (SLSP) and thousand kernels weight (TKW) traits. However, a non-significant difference ($P<0.05$) among the genotypes was observed in their date of emergence (DE), total tiller number (TT) per plot, effective tiller number (ET) per plot, number of kernels per spike (KPSP), number of aborted kernels per spike (ABKPSP), combined grain yield (qt/ha) and combined 12.5% moisture-adjusted-yield (Adj. yield) characters. Additionally, both yield and adjusted yield shown a positive and highly significant correlation ($P<0.05$) with all wheat yield traits except date of heading (DH), spike length (SPL), number of spikelet per spike (SLSP) and number of kernels per spike (KPSP) which shown non significant correlation ($P<0.05$). From the tested 6 wheat genotypes, Gaambo, Utuba and Fentale wheat genotypes gave high and promising mean adj. yields of 28.7 Qt/ha, 27.6 Qt/ha and 27.4 Qt/ha respectively by tolerating adverse effects of the study area. High net incomes of 5598.165 ETB/ha, 4498.165 ETB/ha and 4298.165 ETB/ha was also recorded from the cultivars respectively. Therefore, it is recommended to grow Gaambo, Utuba and Fentale genotypes in Tendaho plantation estate. It is also noted that, Amibara wheat genotype can also be used as an alternative choice in the absence of the above selected genotypes.

Keywords: Adaptation, Correlation, Genotype, Yield.

1. Introduction

Agriculture accounts for about 30 percent of Africa's gross domestic product (GDP) and 75 percent of total employment (World Bank, 2007). Ethiopia has been able to register an average growth rate of 11% over the last seven years in which Agriculture is the main stay of the economy and exports are almost entirely composed of agricultural commodities (FAO, 2014). Accordingly, Ethiopia's agriculture system constitutes 46% of gross national production, employs 85% of its population and creates 75% of export commodity value (FDRE, 2013). In Ethiopian agriculture, cereals are particularly important to the country's food security as they are a principal dietary staple for most of the population; they also comprise about two-third of the agricultural GDP and one-third of the national GDP and are a source of income for a majority of the people (Oumer, 2016). Among cereal crops, wheat has played a fundamental role in human civilization and has contributed to improving food security at global and regional levels (Usman Kedir, 2017). It is also one of the most important cereals cultivated in Ethiopia (Jemal Abdulkerim *et al*., 2015). It ranks fourth after tef (Eragrostis tef), maize (Zea mays) and sorghum (Sorghum bicolor) in area coverage, while third in total production after maize, sorghum and tef (CSA., 2012).

However, the country received significant food aid and became highly dependent on food imports (Croppenstedt *et al*, 1999). In 1995, FAO estimated that food imports will grow at 6% per year and will reach 2.5 million tons by 2010 (Takele, 1996). The fact that Ethiopia has become increasingly dependent on external sources of food supply has become a major concern for policy makers and agricultural researchers. Therefore, the question of how to make Ethiopia self-reliant in food production has received major attention in recent years (EARO, 2000). But, most of the potentially irrigable lands are located in sparsely populated lowland areas where there is high temperature and poorly developed infrastructures (Hailu, 2008).

Even if about 66% of the total land is potentially arable, out of which only 22% is currently under cultivation and only 4% of irrigable lands is currently utilized (EARO, 2000). But, the irrigation potential of the country is over 3.5 million ha (Legesse, 1998). However, recent studies suggested that international investors are making large-scale acquisitions of farmland in areas of Ethiopia (CSA, 2009). Of the approved documented projects, it is estimated that approximately 603,000 hectares are under contract with government leases for up to 50 years (Cotula *et al*. 2009). Moreover, the Government of Ethiopia has started several development projects, in which making the nation among the top ten sugar producing countries of the world by 2025 (GTP2) is among the huge plans. Hence, Ethiopia Sugar Corporation is working irrigation infrastructures for about 420, 000 ha of land in Omo, Awash, Beless, Omo and Tekeze rivers basins (GTP-1) by establishing ten new sugar factories in different parts of the country (Adaptation and Promotion project document, 2016).

Among newly established sugar estates Tendaho has about 50,000 ha farm land size and much of the irrigable land was not yet cultivated by sugarcane due to several reasons. But the global experiences showed that most of the sugar producing countries such as India, Switzerland, Thailand, Australia, South Africa and Brazil are running their sugar industries with complementary crops and livestock's enterprises (Adaptation and Promotion project document, 2016). In Switzerland of Komati downstream development project, ten business entities of livestock business, poultry, piggeries and gardens were effectively formed (FAO, 2005). In this regard, the Ethiopian Sugar Corporation is exerting efforts on complementary crop development with sugarcane with crop, horticulture and livestock production to enhance product diversification. Hailu (2008) reported that low yield due to low adoption of improved agricultural technologies is believed to be the main factor that prevented agricultural production from coping with the rapid population growth in Ethiopia. Since the intended large fertile irrigable low land areas owned by the sugar estates, they have not been addressed by the national agricultural research systems in developing improved crop varieties yet. So, it is essential to undertake a quick adaptation trial in the area for selection and promotion of irrigated wheat genotypes which are ecological suitable, easily adaptable and economically profitable.

Different review of literatures related to the effect of temperature to wheat growth, heading, maturity and yield were reported from different researchers. Accordingly, 31 °C was the upper limit (T_{max}) in which wheat could tolerate during anthesis but T_{max} can be increased to between 33 and 37 °C during the grain filling phase (Stone and Nicolas, 1995). Optimum temperature for wheat grain development ranges from 15 to 25^0C was also reported by Porter and Gawith (1999). Negassa *et al.* (2013) also stated as the minimum, optimum and maximum average temperature at which the plant will grow optimally is 15 ^{0}c, 23 ^{0}c and 27 ^{0}c respectively. The mean average 55 years temperatures of Tendaho sugarcane plantation estate on November, December, January, February and March months ranged between 22.7 ^{0}C (minimum mean temperature) and 26.7 ^{0}C (maximum mean temperature) which is in similar manner with the reports of Negassa *et al* (2013), Stone and Nicolas (1995) and Porter and Gawith (1999). This can lead the country to use its potential for crop production. This also ensured to the Ethiopian sugar corporation to potentially produce wheat in Tendaho and other sugarcane plantation estates.

Crop adaptation is determined primarily by genotype-environment interaction. However, the suitability of a crop to a particular region depending largely on the climatic features of the region in relation to the requirements for normal growth and development of the crop. It has been stressed that most farm-level adaptation responses may counterbalance impacts at low-to-medium temperature increases, allowing for coping with up to 1-2 ^{o}C local temperature increases (Howden *et al.,* 2007). For promotion purpose, the selection of appropriate crop genotypes for commercial production depends on economic factors as well as on the likely performance of the selected crop genotypes in the production environment. Accordingly, an experiment on adaptation performance of 6 wheat genotypes were evaluated for two consecutive years using furrow irrigation with the objective of evaluating the adaptation ability of wheat genotypes to identify high yielding and heat tolerant wheat genotypes that could easily adapt Tendaho sugarcane plantation estate agro-ecology in order to enhance the net national crop production in general and product diversification in sugar estates in particular in the near future.

2. Materials and Methods

2.1. Description of the Study Area

Tendaho sugarcane plantation estate is found in Afar regional state, north eastern part of Ethiopia, that is located at 41°3’E longitude and 11°50’ N latitude, receiving annual rainfall of about 200 mm with mean minimum and maximum temperature of 22.91°C and 37.72°C, respectively. The altitude of the area is 374 m above sea level. The dominant soil type is Fluvisols followed by Vertisols. According to WWDSE (2005), soils of Tendaho are derived from different parent materials mainly from recent alluvium (near Assayita), Lacustrine sediments or oldalluvium (near Dubti) and young reverine alluvium (left and right bank of Awash River).

2.1.1. Temperature of the Study Area

Table 1: Fifty-five Years (Jan. 1953 – Dec. 2017) Monthly Mean Maxi., Mean Mini. and Mean Average Temperature of Tendaho Sugarcane Plantation Estate

Temperature (^{0}c)	JAN	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Mean
Mean Max.	33.0	35.9	38.4	39.9	40.9	41.8	42.8	41.5	39.8	40.2	37.1	34.8	38.8
Mean Mini.	12.4	13.9	15.0	17.1	18.3	20.1	20.5	20.3	20.1	16.6	13.9	13.0	16.8
Mean Average	22.7	24.9	26.7	28.5	29.6	30.9	31.6	30.9	30.0	28.4	25.5	23.9	27.8

Source: Tendaho Research and Development Center

2.1.2. Soil Condition of the Study Area

Dubti area was previously cultivated by Tendaho state farm enterprise since about 56 years back using furrow irrigation. Soil and land suitability study of Dubti farm classified as marginally suitable (S3s) with limitation of soil characteristics (WWDSE, 2007). The result of Zeleke *et al.* (2015) revealed that the current status of Dubti area soil is characterized as high pH, low electrical conductivity (ECe) and very high Cation exchange capacity (CEC) with dominance of magnesium and sodium typically which implies sodic soil. Sleshi (2016) also reported more than 80% of Tendaho state farm (Dubti) is dominated by salt affected soils (27.14% saline, 29.22% saline sodic and 23.36% sodic soils). He also mentioned that the soil pH was qualified under strongly alkaline (>8.5) in irrigated soils while moderately alkaline (8.08 – 8.20) in non- irrigated soils. Hence, the field in which the experiment has been done was one of these irrigated fields and therefore, this adaptation evaluation trial was done under this soil condition.

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2.1.3. Water Requirement of Wheat Crop of the Study Area

The water requirement of wheat was determined for the growing season of 90 days using the CROPWAT computer program with input data of climate, soil and crop from the experimental site. The average reference evapo-transpiration (ET_o) of the site was found to be 5.56 mm/day. The average field capacity and permanent wilting point of the experimental site were found 39.2 and 21.5 respectively. The total available water of the soil was estimated 177.0 mm/m. Net irrigation requirement of the crop was calculated using the CROPWAT computer program based on Allen *et al.* (1998), and the gross irrigation requirement was calculated with the assumed application efficiency of 60%. The computed net and gross irrigation requirements and irrigation schedule of Tendaho sugarcane plantation estate (Dubti site) are presented in Table 2.

Table 2. Irrigation events and crop water requirement of wheat of the experimental site

Date of irrigation	Day	Stage	ETo mm/day	Kc Coeff.	ETc fract.	Depl (%)	Net Irr (mm)	Gr. Irr (mm)
24-Nov	1	Init	4.90	0.3	1.47	59	16.6	27.7
3-Dec	10	Init	4.73	0.3	1.42	49	18.1	30.2
14-Dec	21	Dev	4.62	0.39	1.8	49	23.3	38.9
24-Dec	31	Dev	4.58	0.72	3.3	51	29.6	49.3
2-Jan	40	Dev	4.57	1.04	4.75	56	37.7	62.8
10-Jan	48	Mid	4.55	1.11	5.05	56	40.3	67.1
18-Jan	56	Mid	4.70	1.11	5.22	56	40.4	67.3
26-Jan	64	Mid	4.88	1.06	5.17	58	41.4	69.1
3-Feb	72	Mid	5.03	0.66	3.32	58	41.6	69.4
11-Feb	80	End	5.28	0.4	2.11	55	39.5	65.8
							328.5	**547.6**

Based on this output, the seasonal net and gross irrigation requirement was found to be 328.5 and 547.6 mm respectively.

2.2. Experimental Designs and Treatments

2.2.1. Experimental Design

Six wheat genotypes were tested in randomized complete block design (RCBD) with three replications following appropriate statistical procedure. These experiments aimed to evaluate adaptation ability and yield potential of the candidate genotypes and to identify the best performing wheat genotypes under Tendaho condition. The plot size of the trials were 10 m by 10 m (100 m^2) and the spaces between each replication and plot were 2 m and 1.2 m respectively. The trials were carried out using furrow irrigation from November 2016 to April 2017 (Year one) and November 2017 to end of March 2018 (year 2). Field preparation and other agronomic practices were implemented following to the released wheat production package. 60 cm furrow width was used in the trial. Similarly, 125 qt/ha seed rate was used following drilling sowing method. Fertilizer application was also made according the recommendation made in its package. DAP was also applied at sowing time at the rate of 50 kg/ha and UREA was applied in the rate of 150 kg/ha in two splits in which half was applied at sowing time and the remained at early tasseling stage. Irrigation was given continuously at 8-12 days interval up to the end of maturity according the growth stage of the crop. Continuous inspection of disease and insect pests was made at an interval of 3 days. Weeding was also made manually.

2.2.2. Treatments (Materials)

Six wheat genotype candidates, viz., Amibara, Fentale, Worer-2, Gaambo, Utuba and Mangudo genotypes were used for the wheat genotype adaptation evaluation trial in two years (2016/7 and 2017/8). These genotypes were found from the Ethiopian Institute of Agricultural Research together with their full production package. They were developed and released nationally to be produced in the agro ecologies of lower awash valley warm climates and low altitudes.

2.3. Methods of Data Collection

The following Crop performance data were collected from the trial following the below listed procedures; i.e.

Number of total tillers per plot (TT): The total tiller populations were recorded from five randomly taken samples using $1m^2$ quadrants in each plot and converted to plot basis before time of heading.

Number of effective tillers per plot (ET): The total Effective tiller populations were recorded from five randomly taken samples using $1m^2$ quadrants in each plot and converted to plot basis after heading.

Plant height (PLH): plant Height in centimeter was measured from ground level to the top of the spike excluding the awn of twenty randomly taken plants from all rows of the plot and recorded as the average height per plant.

Panicle length (PL): The main spikes from twenty sampled plants of each plot were measured in cm and averaged to represent the spike length in cm.

Number of spikelet's per panicle (SLSP): The number of spikelets in main tillers of each of the twenty randomly taken plants was taken and averaged to represent the number of spikelts per plant.

Number of normal kernels per panicle (NKSP): The number of normal seeds in each panicle was recorded from 20 plants randomly selected plants in each plot and averaged to represent number of normal (fully filled grain) seeds per single panicle.

Number of Aborted kernels per panicle (ABKSP): The number of Aborted seeds (seeds did not filled its grain) in each panicle was recorded from 20 plants randomly selected plants in each plot and averaged to represent number of aborted seeds per single panicle.

Days to emergence (DE): Number of days from sowing up to the date of 50% germination of the plant in a plot was recorded in plot basis.

Days to heading (DH): The number of days from sowing up to a date when 50% of the plants in a plot had produced spikes was recorded in plot basis.

Days to maturity (DAM): The number of days from sowing to physiological maturity where 8% of the plants became mature in each plot and when 85% of the crop stands; stems, leaves and floral bracts changed to light yellow color was recorded in plot basis.

Thousand-kernel weight (TKW): Grain weight of thousand seeds sampled at random from total grain harvest of the experimental plot was recorded by analytical balance expressed
in gm.

Grain Yield (GY) per hectare: The grain yield in kilo gram at 14 % seed moisture content obtained by harvesting the whole plants from each plot and measured per plot basis and converted to quintals per hectare basis.

2.4. Method of Data Analysis

The two years data obtained from different traits was statistically analyzed using Gen Stat 15th Edition Software. Combined Years data Analysis of Variance for RCBD design was computed for the characters such as date of emergence (DE), date of heading (DH), date of maturity (DM), number of tillers population per plot, number of effective tillers per plot (ET), plant height (PLH), Spike length (SPL), number of spikelet per spike (SLSP), Number of normal kernel per spike (NKSP), number of aborted kernels per spike (ABKSP), yield (qt/ha) and thousand seeds weight (gm). Mean comparisons among treatment means were made by Least Significance Difference (LSD) methods at 5% levels of significance. Moreover, The correlation coefficient of yield, adjusted yield and yield traits of tested wheat genotypes were analyzed using SAS software. The water requirement of wheat was also determined for 90 days growing season using CROPWAT computer program with input data of climate, soil and crop from the experimental site. The RCBD design analysis of variance was used to derive variance components as stated by Cochran and Cox, (1957).

3. Results and Discussion

3.1. Ecological Adaptation

The fifty five years meteorological data analysis result revealed that the mean average temperatures for May, June, July, August and September were 29.6, 30.9, 31.6, 30.9 and 30.0 ^{0}c respectively which are considered as very high. However, relatively low average temperatures were recorded for November, December, January, February and March with 25.5, 23.9, 22.7, 24.9 and 26.7 ^{0}c mean temperatures respectively (Table 1, Figure 1).

As indicated in Table 1, the mean minimum temperatures of November (13.9 ^{0}**c**), December (13 ^{0}**c**), January (12.4 ^{0}**c**), February (13.9 ^{0}**c**) and March (15 ^{0}**c**) are coincided with the result of Negassa *et al.* (2013) that was reported as the minimum average temperature at which the plant will grow optimally is 15 ^{0}**c**. Moreover, average temperature of November (25.5 ^{0}**c**), December (23.9 ^{0}**c**), January (22.7^{0}**c**), February (24.9 ^{0}**c**) and March (26.7 ^{0}**c**) is also similar with the report of Negassa *et al* (2013) as they reported maximum average temperature at which the plant will grow optimally is 23^{0}c and maximum average temperature at which the plant will cease to grow is 27 ^{0}c. As the result revealed above, the Tendaho specific agro-ecology temperature character is similar with ME5, irrigated, low humidity; coolest quarter mean min temp >11^{o}C <16^{o}C as similar as Sudan and Somalia (Negassa *et al.*, 2013).

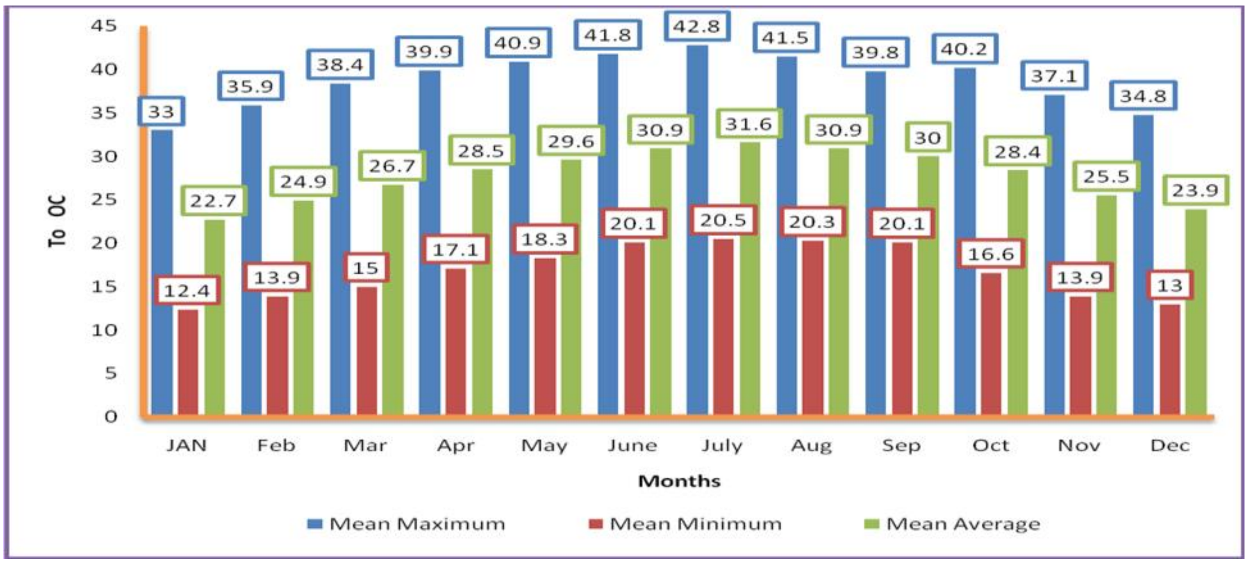

Figure 1. 55 years mean minimum, average and maximum T^{o} of Tendaho Plantation Estate

3.2. Analysis of Variance

The average result of both years analysis of variance shown a significant variation ($p \leq 0.05$) among the tested wheat genotypes due to their date of heading (DH), date of maturity (DM), Plant height (PLH), Spike length (SPL), number of spikelet per spike (SLSP) and thousand kernels weight (TKW) traits. However, a non-significant difference ($P<0.05$) among the cultivars was observed in their date of emergence (DE), total tiller number (TT) per plot, effective tiller number (ET), number of kernels per spike (KPSP), number of aborted kernels per spike (ABKPSP), combined grain yield (qt/ha) and combined 12.5% moisture-adjusted-mean grain yield (Adj. mean yield) characters.

Morphological traits provide a simple way of measuring genetic diversity while studying genotype performance under normal growing conditions but are influenced by environmental factors (Fufa *et al*., 2005). These results pointed to the existence of wider variations among the studied wheat genotypes for their studied characters. Therefore, simple selection was used based on those characters.

Table 3: Two years combine data analysis of variance result for irrigated wheat adaptation evaluation trial in Tendaho 2016/7 and 2017/8

Variance Components	DF	DE (days)	DH (days)	DM (days)	TT (per plot)	ET (per plot)	PLH (cm)	SPL (cm)	NSPLSP (av.plnt)	NKPSP (av.plnt)	ABKPSP (av.plnt)	GY (Qt/ha)	TKW (gm)	Adj.G. Yield
s.s.		0.2222	522.889	186.25	3.81E+08	1.48E+08	1586.77	40.55	42	229.22	5.222	128.28	505.757	99.34
m.s.	5	0.0444	104.578	37.25	7.61E+07	2.96E+07	317.35	8.109	8.4	45.84	1.044	25.66	101.151	19.87
F pr.		NS	<.001	0.028	NS	NS	<.001	0.003	0.015	NS	NS	NS	<.001	NS

Where: s.s = sum of squire, m.s = mean squire F.pr = calculated probability, DE = Days of Emergence, DH= Days of Heading, DM=Days of Maturity, TT=No̲ of Total Tillers, ET=No̲ of Effective Tillers, PLH=Plant Height, SPL= Spike length, SLSN =No̲ of spikelet per spike, TKW = Thousand kernel weight, GY=Grain Yield and Adj. Yield = Moisture-Adjusted-Yield_12.5%.

Table 4: Two Years Combined Mean values, Grand mean, LSD and CV of six irrigated wheat genotypes for thirteen studied traits in two years (2016/7-2017/8)

Entries	**DE (days)**	**DH (days)**	**DM (days)**	**TT (per plot)**	**ET (per plot)**	**PLH (cm)**	**SPL (cm)**	**NSPLSP (av.plnt)**	**NKPSP (av.plnt)**	**ABKPSP (av.plnt)**	**GY (Qt/ha)**	**TKW (gm)**	**Adj. Yield**
Amibara	4.167	50	83.67	54813	43387	81.38	8.37	17	44.33	3.33	30.42	39.13	26.8
Fentale	4.167	46.67	82.17	60443	41030	83.61	8.43	17.17	41	3.67	31.08	36.82	27.4
Gaambo	4.167	54.5	87.83	59733	39167	87.68	8.64	18	44.5	3.33	32.67	46.19	28.7
Mangudo	4.167	54.5	88.83	51420	37403	83.12	5.98	15.17	39	2.5	28.33	46.03	24.9
Utuba	4.333	56.17	85.33	53290	37827	83.56	6.89	16.67	40.83	3	31.33	43.37	27.6
Werer-2	4.333	46.83	85.67	55700	40267	66.79	6.42	15	37.67	2.83	27.08	38.21	23.8
GM	4.222	51.44	85.58	55900	39847	81.02	7.46	16.5	41.22	3.11	30.15	41.62	26.5
LSD	0.6934	3.333	4.194	9944.8	7505.5	5.554	1.541	1.848	6.033	1.616	5.418	2.726	4.77
S_E	0.551	4.275	2.493	7419.7	3638.8	3.242	0.25	0.673	2.075	0.896	3.6	3.883	3.3
R^2	0.79	0.77	0.82	0.83	0.81	0.88	0.98	0.9	0.9	0.81	0.86	0.67	0.82
Sign. level	NS	**	*	NS	NS	**	*	*	NS	NS	NS	**	NS
CV	13.9	5.5	4.1	15.1	16	5.8	17.5	9.5	12.4	44	15.2	5.5	15.2

3.3. Two Years Mean Value of Yield Components and Adjusted Yield Comparison of Tested Irrigated Wheat Genotypes

3.3.1. Mean values of Date of emergence (DE), date of heading (DH) and date of maturity (DM) of irrigated wheat genotypes traits

A non-significance difference at (P<0.05) probability level was recorded in the tested wheat genotypes in terms of their date of emergence. 50% of all the tested genotypes were germinated at statistically similar time which was about 4 days after sowing. However, the tested wheat genotypes differ significantly (P<0.05) in their date of heading and maturity. Wheat genotypes Fentale (46.67 days), werer-2 (46.83 days) and Amibara (50 days) registered relatively earlier date of heading and maturity as compared to the other tested genotypes. This indicates these genotypes are early maturing genotypes in which they mature before 85 days after sowing (Table 4) while werer-2, Gaambo and Mangudo genotypes mature in about 86, 88 and 89 days after planting respectively. According the report made by Wheeler *et al.* (2000), changes in mean temperatures can shorten the time to maturity of a crop, thus reducing yield. This is due to the reason that rising temperatures will decrease the length of grain-filling period of wheat and other small grains (Chowdhury and Wardlaw, 1978). Increases of temperature above 25 to 35^{o}C during grain filling of wheat will shorten the grain filling period and reduce wheat yields (Hatfield *et al*., 2011). When these temperature increases are extrapolated to the global scale a 5.4% decrease in wheat yield per 1 ^{o}C increase in temperature is expected (Lobell and Field, 2007).

3.3.2. Means Values of Tiller population (TT), effective tiller production (ET), spike length (SPL), plant height (PLH), spikelet number per spike (SLPSP), number of normal kernels per spike (NKPSP) and number of aborted kernels per spike (ABKSP) of irrigated wheat genotypes

The tested wheat genotypes significantly differed (P<0.05) in their plant height, spike length, number of spikelets per spike and thousand seeds weight. However, the tested genotypes were statistically similar (P<0.5) in their total tiller production, effective tiller production, number of normal kernels per panicle and number of aborted kernels per spike. As indicated in Table 4, almost all the tested cultivars produce statistically similar total tiller production, effective tiller production, number of normal kernels per panicle and number of aborted kernels per spike. In the other case, the genotypes differ in their height, spike length, number of spikelets per spike and thousand seeds weight. Gaamboo (8.64 cm), Fentale (8.43 cm) and Amibara (8.37) genotypes registered higher spike length, plant height and number of spikelet per spike while Werer-2 and Mangudo genotypes produced lower spike length (6.45 cm, 5.98 cm), plant height (66.79 cm, 83.12 cm) and number of spikelet per spikes (15, 15.17) respectively. Minimum temperature above 68 °F (20 ^{0}C) caused a decrease in spikelet fertility; grains per spike and grain size (Hatfield *et al.,* 2011). Therefore, the wheat production period of Tendaho plantation estate, viz., November to February with minimum temperature of 13.9-15 ^{0}C is highly coincided with the standard given by Hatfield *et al.* (2011) which approved that 20 ^{0}C is comfortable for filling spiklets and florets to produce large sized grains. But, exposure to 36/31 ^{o}C temperatures for only 2 to 3 dates before anthesis can create small unfertilized kernels with symptoms of parthenocarpy, small shrunken kernels with notching and chalking of kernels (Tashiro and Wardlaw, 1990).

3.3.3. Means Values of Grain Yield (qt/ha), Adjusted Mean Grain Yield (qt/ha) and Thousand Kernel/seed Weight (gm/1000 seeds)

A non-significant difference (P<0.05) among the tested wheat genotypes was observed in terms of mean grain yield (Qt/ha) and adjusted mean grain yield (Qt/ha). However, significant difference (P<0.05) was observed in the tested treatments due to their thousands kernel/seed weight (gm/1000 seeds).

Even though all the tested wheat genotypes produced statistically similar mean grain yields (Qt/ha), Gaambo gave comparatively highest mean yield (32.67 Qt/ha) and adj. mean yield (28.7 Qt/ha) followed by Utuba (31.33 Qt/ha and 27.6 Qt/ha) and fentale (31.08 Qt/ha and 27.7 Qt/ha) respectively. The reasons for getting highest combined mean and adjusted mean yields from these genotypes are due to their highest effective tiller production, plant height, spikelet length, number of spikes per spike, number of normal kernels per spike and thousand kernels weight. This result coincides with the result reported by Chatterjee and Maiti (1985) in which yield attributes of cereal crops consists of number of panicles per unit area, number of spikelets (florets) per panicle, percent (ripened) spikelet and thousand grain weight. Among all the yield attributes of wheat, panicle number per m^{2} is highly correlated with grain yield and it is the most important factor that causes variation in grain yield (Miller *et al*., 1991; Thankur, 1993).

They have also shown earlier time of heading and maturity periods. This confirmed the result of Tewolde *et al.* (2006) that found early heading genotypes could perform better compared to latter heading cultivars where heat stress or high temperature occurred after anthesis due to the reason that early heading cultivars have a longer post heading period enabled them to have greater grain filling period and completed their grain filling earlier when air temperature is lower which is more favorable by escaping the most severe effects of heat stress compared to later heading genotypes. However, comparatively lowest combined mean and adjusted mean yields were recorded from Werer-2 (27.08 Qt/ha and 23.8 Qt/ha) followed by Mangudo (28.33 Qt/ha and 24.9 Qt/ha) and Amibara (30.42 Qt/ha and 26.8 Qt/ha) genotypes respectively (Table 6). This may be due to their lowest number of plant height, spikelet length, number of spikes per spike and number of normal kernels per spike. In case of thousand kernels weight (TKW); Gaambo, Mangudo and Utuba produced highest TKW while Fentale, Werer-2 and Amibara produce lower TKW respectively (Table 4).

3.4. The Two Years Mean Value Comparison:

The 2016/7 data analysis result as indicated in Table 5 shown the existence of wide variation among wheat genotypes ($p<0.05$) for grain yield per hectare (GY (qt/ha)). The mean separation result revealed that the candidate genotypes of Gaambo (28.3 qt/ha) and (Utuba 28.3 qt/ha) scored significantly higher mean value followed by Mangudo (27.3 qt/ha) and Werer - 2 (25.7 qt/ha) genotypes. However, Fantalle (23.7 Qt/ha) gave lowest yield followed by Amibara (24.7 Qt/ha) and Werer-2 (25.7 Qt/ha) respectively. However, as shown in Table 5 of 2017/8 data analysis result, all the tested wheat genotypes produce statistically similar grain yield (Qt/ha). But, Fentale gave comparatively highest yield (38.5 Qt/ha) followed by Gaambo (37 Qt/ha) and Amibara (36.2 Qt/ha) respectively in the agro-ecology of Tendaho plantation estate. Comparatively lowest yields were also registered from Werer-2 (28.5 Qt/ha), Mangudo (29.3 Qt/ha) and Amibara-2 (33.3 Qt/ha) respectively (Table 4 and 5).

According to the two years combined analysis result as indicated in Table 6; Gaambo gave comparatively highest combine mean and adjusted mean yields (32.67 and 28.7 Qt/ha) followed by Utuba (31.33 and 27.6 Qt/ha) and Fentale (31.08 and 27.4 Qt/ha) respectively in the study area. Low combine mean and adjusted mean yields were also recorded from Werer-2 (27.08 and 23.8 Qt/ha), Mangudo (28.33 and 24.9 Qt/ha) and Amibara (30.42 and 26.8 Qt/ha) respectively.

Table 5: Separate year Mean Comparison of Six Irrigated Wheat Genotypes for Grain yield (Qt/ha) at Tendaho (2016/7- 2017/8)

Genotype	Year one (2016/7)	Genotype	Year Two (2017/8)
	Grain Yield Qt/ha		Grain Yield (Qt/ha)
Amibara	24.7	Amibara	36.2
Fentale	23.3	Fentale	38.5
Gaamboo	28.3	Gaamboo	37
Werer-2	25.7	Werer-2	28.5
LSD	**1.5**	**LSD**	**9.26**
CV	**2**	**CV**	**15.1**

Table 6: Two Years average grain yield (qt/ha) and Moisture-Adjusted- mean grain Yield comparison

Variety	Separate years productivity (qt/ha)		Average Mean of both years (qt/ha)	
	1996/7	1997/8	Grain Yield	Adj. Grain Yield
Gaamboo	28.3	37	32.67	28.7
Utuba	28.3	34.3	31.33	27.6
Faantalle	23.7	38.5	31.08	27.4
Amibara	24.7	36.2	30.42	26.8
Mangudo	27.3	29.3	28.33	24.9
Worer-2	25.7	28.5	27.08	23.8
LCD	**1.5**	**9.26**	**5.418**	**4.77**
CV	**2**	**15.1**	**15.2**	**15.2**

3.4.2. Economic Advantage of Wheat Production

As indicated in Table 7, the comparative yield advantage (Qt/ha) and percentage of yield advantage (%) of the tested wheat genotypes ranged between 9.8 and 14.7 Qt/ha and 70 and 105% respectively as compared to the average national productivity of 14 qt/ha (CSA, 2015). Genotypes with highest percentage of yield advantages were Gaambo (105%), Utuba (97.1%) and Fentale (95.7%) respectively while the cultivar with lowest percentage of yield advantage was Werer–2 (70%) followed by Mangudo (77.9%) and Amibara-2 (91.4%) respectively.

Table 7: Comparative Yield Advantage of Two Years Tested Wheat Genotypes over the National Average (14 Qt/ha*)

Wheat genotypes	Combined Adj. mean (Qt/ha)	Average national productivity (Qt/ha)	Comparative Yield advantage (Qt/ha)	Yield Advantage (%)
Gaamboo	28.7	14	14.7	105
Utuba	27.6	14	13.6	97.1
Fentale	27.4	14	13.4	95.7
Amibara	26.8	14	12.8	91.4
Mangudo	24.9	14	10.9	77.9
Werer - 2	23.8	14	9.8	70
LSD	4.77			
CV	15.2			

Where: * CSA, 2015 indicated that 14 qt/ha were national productivity

3.4.3. Profit Analysis of Wheat Production

The economic analysis result shown that production of wheat could provide additional income to Tendaho sugarcane plantation estate with net profit per quintal of 55.9 ETB, 44.9 ETB and 42.9 ETB when Gaambo, Utuba and Fentale wheat genotypes are used. With the highest adjusted mean yield of 28.7 Qt/ha of Gaambo wheat genotype, the net profit will be 5598.16 birr per hectare by considering the current minimum selling price of 1000 ETB/Qt (cost in which the commercially produced wheat in 700 ha was sold). We can project the current finding to calculate the net profit before tax by producing 1000 hectares in Tendaho, with this simple analysis the profit could be 5,598,165 ETB per three months. Additionally, the by-products of wheat can also be sold for animal forage. This could be additional income to the factory in specific and corporation in general.

Table 8: Profit analysis of wheat production at Tendaho sugarcane plantation estate

Parameters	Gaamboo	Utuba	Fentale	Amibara	Mangudo	Wer-2	GM
Adj. Yield (Qt/ha)	28.7	27.6	27.4	26.8	24.9	23.8	26.5
TPC(ETB/ha)	23101.84	23101.835	23101.835	23101.84	23101.84	23101.84	23101.84
SP(ETB/Qt)	1000	1000	1000	1000	1000	1000	1000
GI (ETB/ha)	28700	27600	27400	26800	24900	23800	26500
NP(ETB/ha)	5598.165	4498.165	4298.165	3698.165	1798.165	698.165	3398.165
NP (ETB/Qt)	55.98165	44.98165	42.98165	36.98165	17.98165	6.98165	33.98165

Where; Fen-2 = Fentale-2, Amiba-2 = Amibara-2, Wer-2 = Werer-2, GM = Grand mean, TPC = Total Production Cost, SP = Selling Price, GI = Gross Income and NP=Net profit

3.5. Simple correlation coefficient among yield components of wheat

Correlation coefficients between the different pair of yield traits of the tested wheat genotypes were calculated to find the relationship among the various yield traits studied as presented in below, Table 9.

Table 9. Correlation coefficients of 11 wheat yield traits of 5 wheat genotypes grown at Tendaho sugarcane plantation estate

	DH	DM	PLH	ET	SPL	SLSP	NKSP	ABKSP	YLD	TKW	Adj. Yld
DH	1										
DM	0.46**	1									
PLH	0.46**	0.35*	1								
ET	-0.16 ns	0.013 ns	-0.01 ns	1							
SPL	-0.07 ns	-0.11 ns	0.11 ns	0.37**	1						
SLSP	0.06 ns	-0.23 ns	0.29 ns	-0.24 ns	0.64***	1					
NKSP	0.12 ns	-0.22 ns	0.20 ns	-0.3 ns	0.39**	0.84***	1				
ABKSP	0.01 ns	0.04 ns	-0.04 ns	0.21 ns	0.63***	0.44***	0.39**	1			
YLD	0.26 ns	0.31*	0.79***	0.41*	0.11ns	0.21ns	0.11 ns	-0.43*	1		
TKW	0.61***	0.61 ns	0.67***	-0.15 ns	-0.11 ns	0.08 ns	0.05 ns	-0.12 ns	0.44**	1	
Adj.Yld	0.26 ns	0.31*	0.79***	0.41*	0.11ns	0.21ns	0.11 ns	-0.43*	1	0.43**	1

As shown in the above table, both mean yield and adjusted mean yield shown a positive and highly significant correlation (P<0.05) with all wheat yield traits except with date of heading (DH), spike length (SPL), number of spikelet per spike (SLSP) and number of kernels per spike (KPSP) which were non-significant (P<0.05). Similarly, thousand kernels weight (TKW) shown a positive and highly significant correlation (P<0.05) with date of heading (DH), plant height (PLH), mean yield and adjusted mean yield of tested genotypes. This result is in agreement with the result of Blanco *et al*. (2001) who found significant positive correlation between thousand seed weight and grain yield (p<0.05) in four out of six population of hexaploid wheat. There was also significant correlation (r=0.84) between number of spikelets per spike with number of seeds per spike which is also similar to the finding of Birhanu (2010). However, both mean yield and adjusted mean yield were positively but non-significantly (p<0.05) correlated (r= 0.11) with spike length which is in contradiction with the result of Pathak *et al*. (1984) who reported as spike length was negatively correlated with grain yield (r= -0.13). Therefore, these traits could be used as indirect selection traits for grain yield according to the significance correlation suggestion.

4. Conclusion and Recommendation

All the tested wheat genotypes shown better adaptation performance to Tendaho agro ecology and shown their adaptation potential by producing above the average national wheat productivity. Even though there is no significant statistical variation among them in terms of combined adjusted mean yield, the studied genotypes gave more yields (ranged from 23.8 Qt/ha for Werer-2 to Gaambo of 28.7 Qt/ha) than the national average (14 qt/ha). But, in terms of economic analysis Gaambo gave higher net profit with 5598.165 ETB/ha (55.98 ETB/qt) followed by Utuba and Fentale with 4498.165 ETB/ha (44.98 ETB/qt) and 4298.165 ETB/ha (42.98 ETB/qt) respectively. Moreover, both mean yield and adjusted mean yield shown a positive and highly significant correlation ($P<0.05$) with all wheat yield traits except date of heading (DH), spike length (SPL), number of spikelet per spike (SLSP) and number of kernels per spike (KPSP) which were non-significantly correlated ($P<0.05$). Therefore, based on the obtained result and the discussion made above, it can be concluded that from the studied genotypes; Gaambo, Utuba and Fentale genotypes shown better adaptation performance and high net income in both consecutive years in Tendaho sugarcane plantation estate using furrow irrigation.

Therefore, it is recommended to produce Gaambo, Utuba and Fentalee wheat genotypes in the study area. It is also noted that, Amibara wheat genotype can be also used as an alternative in the absence of the above selected genotypes. Moreover, due attention should be given to minimize losses at field during harvesting and post harvest handling techniques. So, the grain yield should be immediately sold before damaged by different post harvest pests like weevils, rats etc. Further research works should be also done in developing, selection and adoption of better varieties, irrigation interval, time and amount of fertilizer application, planting time and season in the study area.

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