Performance of exotic summer wheat (*Triticum aestivum)* varieties under Wetland conditions

By

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DECLARATION

I do hereby declare that this dissertation is a result of my own efforts and investigation, and such work has not been presented elsewhere for any degree. All additional sources of information have been acknowledged by means of references

Takawira Ivy ………………… …………………..

Student No. R14753M Signature Date

Certification of thesis work

I, the undersigned, certify that Takawira Ivy, a candidate for Bachelor of Science Agronomy Honours Degree has presented this dissertation with the tittle:

PERFORMANCE OF EXOTIC SUMMER WHEAT (*TRITICUM AESTIVUM)* VARIETIES UNDER WETLAND CONDITIONS

That the dissertation is acceptable in form and content, that satisfactory knowledge of the field covered by the dissertation was demonstrated by the candidate through oral examination held on ……………………...

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ABSTRACT

Wheat is the second most important staple food crop in Zimbabwe after maize. However, because of lack of irrigation infrastructure and high cost of production the country is not meeting national demand and is relying on imports thereby losing a lot of foreign currency. Currently winter irrigated wheat production constitutes more than 90% of the local production. The country's water reserves are also drying up due to low rainfall being received, meaning we cannot increase irrigated area. There is therefore need to explore other ways of increasing wheat production in the country that do not rely on irrigation. Summer wheat had been hindered by lack of suitable varieties with only one commercial variety SC Sahai on the market. With current short rainfall seasons being experienced there is a need to evaluate the performance of the summer wheat varieties under wetlands were they benefit from residual moisture. Agronomic and quality attributes of four summer wheat varieties developed by CIMMYT and are currently cultivated in Ethiopia plus one local check were evaluated under wetlands conditions in Mvuma district of Zimbabwe. The field experiment laid out in a RCBD replicated four times. Wheat varieties were evaluated for yield and its components, growth, quality and disease resistance. Exotic varieties performed significantly better ($p < 0.05$) than Sahai the local variety. Aguilal gave significantly ($p < 0.05$) the highest yield and test density and also had a high number of spikelets. The experiment showed that summer wheat can be grown successfully on wetlands giving better yield and quality and can be used to compliment winter wheat stocks.

DEDICATION

To Michael, Darlene and Michael Jnr.

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I would like to express my immediate indebtedness to my family as an indispensable pillar in all my endeavours. With highest regard to my husband who offered unequaled encouragement and support. In transforming my research ideas into a reality is the overwhelming supervision of the forever vibrant Mr Manjeru. Him is a force to reckon with and thus, I like to extend my heartily respect and acknowledgement for providing proper and probably best ever type of guidance to make the course of my research an interesting period for ever to be missed. Under his management I was able to keep focused to the attainment of desired outcomes. Worth mentioning is amicable relations with different personalities that have mushroomed during my college years. My friends Upenyu Ndoro, Patience Machiva and Innocent Mandizvidza you are indispensable.

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ACRONYMS

A1	Small Scale Farmers
A2	Large Scale Farmers
CBI	Crop Breeding Institute
CFU	Commercial Farmers Union
CIMMYT	International Maize and Wheat Improvement Centre
DDF	District Development Fund
ECA	East Central Africa
EU	European Union
FAO	Food and Agriculture Organisation
FAOSTAT	Food and Agricultural Organisation Statistics
GDP	Gross Domestic Product
GMB	Grain Marketing Board
GNP	Gross National Product
MAMID	Ministry of Agriculture Mechanisation and Irrigation Development
RBZ	Reserve Bank of Zimbabwe
SADC	Southern Africa Development Countries
UDI	Unilateral Declaration of Independence
USAID	United States Aid International Development
ZETDC	Zimbabwe Electricity Transmission and Distribution Company
ZFU	Zimbabwe Farmers Union
ZFC	Zimbabwe Fertiliser Company

CHAPTER 1

INTRODUCTION

1.1Background and Justification

Wheat (*Triticum aestivum L)* is grown on more land than any other crop in the world and continues to be the most important food grain source for humans (Curtis, 2006). In Zimbabwe wheat is the second most important strategic security food crop after maize (Mutambara *et al*., 2013). Wheat is specifically used to make flour and bran. Flour is used for baking and other confectionaries being consumed almost daily by urban Zimbabweans. Bran is mostly used in manufacturing of stock feeds (Kapuya *et al.*, 2010). In Zimbabwe a greater percentage of wheat is grown during the dry winter season under irrigation with a small amount being grown on soils with residual moisture which are wetlands by small scale farmers. Rain-fed summer wheat has also been introduced with one commercial variety Seed co SC Sahai. Summer wheat has low adoption due to lack of suitable varieties (CBI, 2014). Winter wheat production is facing challenges especially high production costs which have led to a significant decline in the level of wheat output in Zimbabwe (Anseeuw *et al.*,2012).The national wheat output for 2014/15 season was estimated at 18 000 metric tonnes whilst the national requirement stands at 400 000 (MAMID 2015). There is need to increase production to at least meet the national demand and reduce the country's import bill.

This can be achieved through increasing area under winter wheat, increasing yield per unit area and also through summer wheat production with the objective of complimenting winter stocks. With climate change, there is a significant reduction in the country's water reserves for irrigation therefore increasing area under wheat is a challenge (Moyo, 2015). Summer wheat has low production costs than winter given the high costs of irrigating in the country which stand at 700 dollars per hectare (CFU, 2016).With climate change and variability being experienced and short rainfall seasons, growing wheat on wetlands gives advantage of residual moisture and fertility. Verhoeven and Setter (2009) postulate that agricultural wetlands from the beginning have been recognized as valuable land areas for food production. These systems therefore could be optimized to produce more food per unit of wetland surface area while conserving the wetland.

1.2 Research Objectives

1.2.1The main objective was to evaluate growth, yield and quality of exotic summer wheat varieties grown under wetland conditions in Zimbabwe.

1.2.2 The specific objectives were;

- To evaluate the growth performance (days to 50% anthesis, days to maturity, final plant height, spike length and awn length) of the exotic summer wheat varieties under wetland conditions in Zimbabwe.
- To evaluate the performance of exotic summer wheat varieties for yield and its components (spikelets per spike, grains per spike and fertile spikelets) under wetlands conditions in Zimbabwe.
- To evaluate disease incidence and severity of leaf and stem rust on the exotic summer wheat varieties under wetland conditions in Zimbabwe.
- To determine the quality (test density and protein content) of exotic summer wheat varieties grown under wetland conditions in Zimbabwe.

1.3 Research Hypotheses

- There is no significant difference on the growth parameters of exotic summer wheat varieties under wetland conditions.

- There is no significant difference on yield and yield components of exotic summer varieties under wetland conditions.
- There is no significant difference in disease incidence and severity of leaf and stem rust on summer wheat varieties under wetland conditions.
- There is no significant difference in the quality of wheat for exotic summer wheat varieties under wetland conditions.

CHAPTER 2

LITERATURE REVIEW

2.1 Wheat types and economic importance

Wheat was one of the first domesticated food crops, since around 3000 to 4000 BC. It originated in the Black Sea basin and Western Asia but can adapt in many environments and as a result it can as well be grown in the tropical regions to nearly the poles. From its primitive form emmer wheat, it has evolved itself in part by nature and in part by manipulation into the presently cultivated species (Curtis, 2002). Hexaploid bread wheat (*Triticum aestivum L.*) and tetraploid durum wheat (*T. turgidum L. var. durum*), are the more important modern wheat species which are different from one another in genomic make-up, in grain composition and in food end use quality attributes (Pena, 2006). Wheat is of the tribe *Triticeae* one of the largest and also important tribes in the grass *Poaceae* family (Dewey, 1984). Classification of wheat into spring or winter is widespread and it refers to the season in which the crop is grown. For winter wheat, heading is delayed until the plant experiences a period of cold winter temperatures which are 0°C to 5°C (Curtis, 2002). Its wide adaptation to diverse environmental conditions, along with its unique characteristic of possessing a viscoelastic storage protein complex called gluten, are the main factors making wheat the most important food crop in the world (Pena, 2006).

Approximately 90 to 95 percent of the wheat produced in the world, (USDA, 1998), is bread wheat (*T. aestivum)*, which is better known as hard wheat or soft wheat, depending on grain hardness. Wheat is utilized mainly as flour which is whole grain or refined, for the production of a large variety of leavened and flat breads, and for the manufacture of a wide variety of other baking products. By-products are used as bran for livestock feed. The rest is mostly durum wheat (*T. durum)*, which is used to produce semolina (coarse flour), the main raw material of pasta making (Pena 2006).

Wheat (*Triticum aestivum L*), in the form of bread, provides more nutrients to the world population than any other single food source. Bread is particularly important as a source of carbohydrates, proteins and vitamins B and E (Pomeranz, 1987).

2.2 Wheat production trends

Land under wheat production is more than any other commercial crops. Its world trade is also greater than other crops combined and its global average productivity is about 2.7 tonnes per hectare with highly variability among countries and regions (Rajaram *et al.*, 2006).Global wheat production grew by an average of 2.18% per year from 222,400 tonnes in 1961to 607,000,000 tonnes in 2007. China and India are accounted for more than 30% of the world wheat crop 2007. Pace of growth of global wheat production have slowed in recent years. From1961-1990, the total quantity of wheat worldwide increased by an average of 3.38% per year. There after (specifically 1961-2007), global wheat grew by 0, 67% per year (Pardey, 2010). This reflects the combined effect of a contraction in wheat area and a slowdown in the growth of average yields. The effect of these broad trends is that an increase in wheat production has failed to maintain pace with the growth in world population (Pardey, 2010). Africa accounts for this deficit where there is reduced irrigation, low yielding varieties and fertiliser use (Samarendu *et al.*, 2009).

Wheat has been always a commodity crop in North Africa and it was the grain basket for the Roman Empire. The wheat production and domestication started in North Africa, Turkey and Iraq (Braun, 2012). African wheat producing countries are Nigeria, South Africa, Sudan, Tanzania, Tunisia, Zimbabwe, Lesotho, Algeria, Egypt, Eritrea, Ethiopia, Kenya, Libya, Morocco and other small countries. In East Africa and North Africa wheat is grown under rain fed conditions expect in countries like Zimbabwe, Zambia, lowlands of Somalia and Egypt, where they produce wheat under irrigation (Braun, 2012). Major wheat producing countries in the ECA region are Tanzania, Kenya, Sudan and Ethiopia. Average wheat production for ECA countries from 1986-2003 was 18, 000,000million on 12,000,000 hectares having an average yield of 1.2 tonnes/hectare (CIMMYT, 2004). Area under wheat has been progressively growing from 1987- 1997 until 2000 when it stagnated. As from 2000 to 2001 there was a rise and there after a decline up to 2003. There is a massive gap between what Africa is producing and what it needs (CIMMYT, 2004)

Studies are indicating that there is need for addressing economic, social and environmental impact of boosting wheat production in rich agricultural lands of Eastern and Southern Africa. As there is a call for increase Ethiopia and Madagascar are already producing new wheat varieties which might increase wheat yields (Singh *et al.,* 2010). Increase in production of wheat is necessary to provide food security in developing countries. Ways to sustain increasing productivity should be explored. It is now realized that sustaining as well as increasing productivity may be essential. (Singh *et al.,* 2010)

In Zimbabwe a greater percentage (more than 90 %) of wheat is grown during the dry winter season under irrigation with a small amount being grown on soils with residual moisture which are wetlands. A small amount is rain fed summer wheat mostly grown by small holder farmers especially those in the eastern highlands of the country (CBI, 2014). Wetlands are areas where there is presence of water either at the surface or within the root zone, seasonally or permanent (Verhoeven and Setter, 2009). There is a call to use wetlands wisely for agriculture in the country. Zimbabwe is a signatory of Ramsar convention which is an inter-governmental treaty which promote conservation and wise use of wetlands (Government Gazette, 2013).Winter wheat has high production costs as a result it is mostly produced by a large to medium scale commercial farmers (Anseeuw *et al*., 2012). The winter varieties are mainly of the spring type and are intermediate between the soft and hard wheat types. Development research by the International Maize and Wheat Improvement Centre (CIMMYT) during the past two decades has shown that wheat production in much warmer areas is technologically feasible hence the development of summer varieties (CBI, 2014). The country's production levels fell from a record high of 340,000 tonnes in 2000 to a record low of about 40,000 metric tonnes in 2011 against a consumption level of about 450,000 metric tonnes per year (Mutambara *et al.,* 2013). Due to a vividly increase in urban population and changing of tastes, there is a widely gap between production and consumption. The implication of this decline in national average output is that, the government would have to commit more funds towards importation of grain to meet local demand. This has a huge bearing on the cash stripped government (Financial Gazette, 2015).

Wheat production can be increased by increasing area under wheat, increasing yield per unit area and production of rain-fed wheat. Looking at climate change and the country's threatened water resources and falling underground reserves, increasing area under winter wheat remains a challenge. The Seed Company of Zimbabwe has released a summer variety called Sahai, which is already under commercial production (CBI, 2014). Crop Breeding Institute has resuscitated the rain-fed wheat breeding programme with the long term objective of complimenting wheat stocks that are produced during winter. Given the current short rainfall seasons, late summer wheat crop can benefit from residual moisture on wetlands. (Wood and Halsema, 2008) cite that wetland agriculture has made a significant contribution to the well being of many societies around the globe. They went on to say wetlands have been, and remain agricultural resource for people in many parts of the world. Wetlands can be used for agricultural purposes without complete reclamation leaving hydrological processes partially intact (Verhoeven and Setter, 2009) .

2.3 Challenges of wheat production in Zimbabwe

The wheat world prices have been unsteady and they are below the country's producer price due to the high production costs in the country. This has a huge negative bearing on the wheat sector. Mutambara, Zvinavashe and Mwakiwa (2013), indicated that wheat flour is coming in at prices that are much lower than the normal price at supply. A number of countries are giving subsidies to their exports, and this will allow the countries to trade at a lower or below cost as a result this affects the Zimbabwean local wheat producers.

High costs of inputs and at times unavailability are some of the major challenges to wheat production in the country. The fertilizer industry in the country is facing production constraints. The country's main producers ZFC, Windmill and Omnia, do not have the capacity to produce enough fertilizer to meet the local demand. They also have to import expensive raw materials in the production of fertilizer which has resulted in low production and high import bill being transmitted to farmers by paying higher prices for fertilizer (Rukuni *et al.*, 2006).

ZETDC's electricity supply remains unreliable and this comes as a strong hindrance to wheat growers who are dependent on irrigation to produce their crop during the dry winter months. ZETDC has failed to maintain a regular power supply to the farmers (IRIN, 2007).

There has been a lot of damage to infrastructure as a result of the land reform program leading to reduced irrigation equipment on the farms (Muchopa, 2006). The Department of Agricultural Mechanization estimates that only about 2 percent of Zimbabwe's arable land is prepared using tractors, down from an estimated 5 percent in2004/05.The destruction of infrastructure and lack of capital to repair the existing equipment has contributed to low production of wheat.

Farmers are also failing to access to credit facilities. Kanyenze (2011) postulates that well developed financial sector is essential in the development of all sectors of an economy be it agricultural or nonagricultural. Financial products which are there on the market are limited and short term. These are not suitable for agriculture, and offered at high interest rates (USAID, 2012). The current situation on landownership rights in Zimbabwe which is not certain has compromised the financial sector's ability to mobilize financial resources from savings for lending to the productive sector at reasonable interest rate (Mutambara *et al*., 2013). Credit institutions do not feel secure to lend farmers money and this has significantly affected wheat production due to failure to secure the much needed capital for sound production.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Site description

The experiment was carried out in Ward 11, Mvuma district of Midlands Province. It is 12km South of Mvuma Rural District Council along Harare- Beitbridge road and 90 km North of Masvingo Town. The site is at Latitude 19°43'S and Longitude 30°51'E and at an altitude of 1400meters above sea level. The average annual temperature for the area is 18.3°c. The warmest month is October with an average temperature of 21.4°c whilst June is the coldest month with an average temperature of 13.2°c. Ward 11 is in Natural region IV (Mugandani *et al*., 2012). The area has an average rainfall of 650mm per annum. Topography of the area is generally broad flat ridges with wide vleis. Soils are fine grained granite sands (Nyamapfene 1991). The site is located in one of the 7 designated Ramsar protected wetlands in Zimbabwe which is Driefontein grasslands

3.2 Experimental design and treatments

The experiment was laid in a Randomised Complete Block Design (RCBD) with 4 replicates and slope was the blocking factor. The experiment consisted of 5 treatments which were wheat varieties shown in table 3.1.

Table 3.1 Table of Treatments

Treatment	Description
1	Aguilal
2	Utique
3	Reyna
4	Quafzah
5	Sahai (control)

3.3Agronomic procedure

3.3.1 Plot size

The plots measured 5 m length and 1.5m width. Each plot had six rows. The trial had a total of 20 plots and measured 150 m^2

3.3.2 Planting

Planting was done on the 16th of February. The wheat was drilled in rows with an inter row spacing of 0.25 m. A hand row marker was used to mark the rows.

3.3.3Fertiliser application

Compound D was applied at planting as a basal fertiliser at a rate of 400 kg/ ha. Top dressing, Ammonium Nitrate was applied at 28 days after emergency at a rate of 300 kg/ ha.

3.3.4 Irrigation

The wheat was grown under rain-fed conditions. The total rainfall received for the four months from February was 139.5 mm. The wheat reached physiological maturity from residual moisture.

3.3.5Weed management

Mechanical weeding was done using hoes. Weeding was done twice. The most problem weeds were black jack, gallant soldier and fat hen.

3.3.6 Harvesting

Harvesting was done at physiological maturity. Two outer rows were discarded on each plot. Plants from the net plot were sickled, bundled and left to dry for four days.

3.4 Measurements taken

Table 3.2: Table of measurements

Trait	Unit	Measurement
Days to emergence	day	Days from planting to 50% emergence
Days to anthesis	day	Days from planting to 50% anthesis
Days to maturity	day	Days from planting to 50% physiological maturity
Plant height	cm	From the ground to tip of the plant
Lodging	%	Number of lodged plants per plot
Tillers		Average number of tillers per plant
Awn length	mm	Average awn length per spike
Spikelets per spike	spikelet	Average number of spikelets per spike
Fertile spikelets	spikelet	Average number of fertile spikelets per spike
Unfertile spikelets	spikelet	Average number of unfertile spikelets per spike
Grain per spike	kernel	Average number of grains per spike
Grain yield	t/ha	Net grain yield per plot
Test density	kg/hl	Mass (g) of wheat in a 500ml bucket/5
Protein content	%	Kjeldahl method using selenium catalyst
Leaf and stem rust		Measuring leaf and stem rust percentage using McNeal rust score

Table 3.3: McNeal *et al* Rust scoring scale

Score	status	description of symptoms
0	Immune	No visible uredia
1	Very resistant	Necrotic flecks
2	Resistant	Necrotic areas without sporulation
3-4	Resistant	Necrotic areas with restricted sporulation
5-6	Moderately resistant	Moderate sporulation with necrosis and chlorosis
7-8	Moderately susceptible	Copulation with chlorosis
9	Susceptible	Abundant sporulation without chlorosis

3.5 Data analysis

Analysis of variance was done using Genstat 14th edition. Separation of means was done using Least Significance Difference (LSD) test at 5% level of significance. Count data was transformed using square root transformation.

Grain yield per plot was converted to tonnes per hectare before analysis using the formula

$$\text{Yield kg/ha} = \frac{10*(100\text{-moisture})*\text{Net yield g/plot}}{\text{Net plot}*87.5}$$

Where 10is a constant

87.5 is a constant

CHAPTER 4

RESULTS

In this study, significant differences ($p<0.05$) were obtained on growth parameters yield parameters and quality parameters (Table 4.1). Sahai had significantly shortest days to reach anthesis and maturity followed by Quafzah and Reyna which were significantly similar then Utique and lastly Aguilal which took the longest. All the exotic varieties took significantly longer days to reach anthesis and maturity than Sahai the control. Utique was significantly taller than all the varieties and Sahai was significantly the shortest. Significant differences ($p<0.05$) were also noted on spike length and awn length (Table 4.1).Aguilal produced significantly longest spikes, followed by Quafzah, Utique and Reyna which were significantly similar and Sahai had significantly shortest spikes. Aguilal had significantly longest awns, Followed by Utique then Reyna and Quafzah which were significantly similar. Sahai the control had significantly shortest awns than the exotic varieties. There were no significant differences in lodging percentage. All varieties recorded zero percent lodging.

Aguilal had significantly increased number of spikelets and fertile spikelets per spike and the highest number of grains per spike than all varieties (Table 4.2). It was followed by Quafzah, Utique and Reyna which were significantly similar. Sahai had significantly the most reduced number of spikelets per spike, fertile spikelets and grains per spike. All the exotic varieties were significantly better than Sahai. Aguilal produced significantly higher grain yield at 5% level than all varieties including Sahai the control. Quafzah, Reyna and Utique produced significantly similar yields. All the exotic varieties performed better than Sahai which produced the lowest grain yield. Sahai yielded 46% lower than Aguilal the highest yielding variety. There were no significant differences in the number of tillers per plant. However Sahai had 45% lower tillers per plant than Aguilal and Utique which had the highest number of tillers.

Aguilal had significantly the highest test density, followed by Quafzah and Utique which were significantly similar then Reyna and lastly Sahai (Table 4.2). All the exotic varieties had significantly better quality than Sahai. There were no significant differences in protein content during separation of means. However Aguilal had the highest protein content followed by Utique then Quafzah and Reyna. All the exotic varieties had higher protein content than Sahai. There were no significant differences in leaf and stem rust. All the varieties scored zero which shows immunity to leaf and stem rust using McNeal *et al* rust scoring.

Table 4.1: Comparative performance of wheat varieties for growth components

	Days to Anthesis	Days to maturity	Plant height (cm)	Spike length (mm)	Awn length (mm)
Aguilal	60.00^{d}	112.5^{d}	92.2^{b}	115.8^{c}	111.8^{a}
Quafzah	51.50^{b}	102.5^{b}	93.0^{b}	106.0^{b}	102.2^{c}
Utique	54.50^{c}	107.0^{c}	102.7^{d}	106.5^{b}	108.0^{b}
Reyna	51.75^{b}	102.5^{b}	96.2^{c}	106.8^{b}	100.5^{c}
Sahai	49.00^{a}	98.0^{a}	89.0^{a}	91.0^{a}	87.2^{d}
P-value	<.001	<.001	<.001	<.001	<.001
LSD	1.502	0.692	0.943	4.059	1.312
CV%	1.8	0.4	0.6	2.5	0.8
Grand Mean	53.35	104.5	94.65	105.2	101.75

Note: The significance level was at 0.05

Table 4.2: Comparative performance of wheat varieties for yield and quality components

	Spikelets spike^{-1}	Fertile spikelets spike^{-1}	Unfertile spikelets spike^{-1}	Grains spike^{-1}	Grain yield t/ha	Test density
Aguilal	16.25^{c}	15.25^{c}	1.225^{a}	37.75^{c}	1.641^{c}	81.35^{d}
Quafzah	14.25^{b}	13.25^{b}	1.225^{a}	36.00^{b}	1.451^{b}	78.05^{c}
Utique	14.25^{b}	13.25^{b}	1.225^{a}	35.75^{b}	1.440^{b}	78.70^{c}
Reyna	14.00^{b}	12.50^{b}	1.403^{b}	35.50^{b}	1.386^{b}	74.20^{b}
Sahai	12.00^{a}	10.25^{a}	1.492^{b}	27.75^{a}	0.884^{a}	67.00^{a}
P-value	<.001	<.001	0.013	<.001	<.001	<.001
LSD	0.579	0.770	0.1736	0.731	0.083	2.293
CV%	2.7	3.9	8.6	1.4	4.0	2.0
Grand Mean	14.15	12.90	1.314	34.55	1.361	45.86

Note: The significance level was at 0.05

In table 4.3, significant correlations were identified on growth and yield parameters to yield. Spike length (SL) and awn (AL) length showed a significant positive correlation with days to maturity (DM), number of spikelets per spike (NSS) and grain yield. There was also a significant positive correlation of spike length (SL) to plant height (PHL). However awn length did not have a significant correlation to plant height. Number of spikelets and number of fertile spikelets (NFS) showed a highly positive significant correlation to number of grains per spike and grain yield. However number of spikelets and number of fertile spikelets did not have a significant correlation to plant height. Number of grains per spike (GPS) showed a highly significant positive correlation to grain yield but did not have a significant correlation to plant height. Awn length showed a highly positive significant correlation with test density. Positive significant correlations with test density were also shown on number of spikelets per spike, number of fertile spikelets, grains per spike and grain yield.

Table 4.3: Correlation coefficiences for pooled data on yield and yield components

	plh	de	sl	da	dm	mois	gw	yield	nt	gps	nss	al
plh	1.0000											
de	0.0871	1.0000										
	0.7150											
sl	0.5216*	0.2178	1.0000									
	0.0183	0.3564										
da	0.4261	0.2325	0.8439*	1.0000								
	0.0610	0.3238	0.0000									
dm	0.3954	0.2956	0.8804*	0.9557*	1.0000							
	0.0844	0.2058	0.0000	0.0000								
mois	0.0983	-0.0581	0.1443	0.1387	0.1067	1.0000						
	0.6800	0.8077	0.5440	0.5597	0.6545							
gw	0.3333	0.3777	0.7145*	0.8674*	0.8711*	0.0296	1.0000					
	0.1510	0.1006	0.0004	0.0000	0.0000	0.9013						
yield	0.3361	0.3468	0.7032*	0.8560*	0.8642*	-0.0695	0.9917*	1.0000				
	0.1474	0.1341	0.0005	0.0000	0.0000	0.7708	0.0000					
nt	0.5071*	0.3627	0.5845*	0.8319*	0.7848*	0.0933	0.8522*	0.8524*	1.0000			
	0.0225	0.1160	0.0068	0.0000	0.0000	0.6957	0.0000	0.0000				
gps	0.2204	0.3655	0.6892*	0.8190*	0.7971*	-0.0159	0.8952*	0.8889*	0.7821*	1.0000		
	0.3503	0.1131	0.0008	0.0000	0.0000	0.9469	0.0000	0.0000	0.0000			
nss	0.3001	0.2798	0.6709*	0.8734*	0.7855*	0.0159	0.9153*	0.9105*	0.8050*	0.9048*	1.0000	
	0.1986	0.2323	0.0012	0.0000	0.0000	0.9471	0.0000	0.0000	0.0000	0.0000		
al	0.4124	0.3500	0.6799*	0.9123*	0.8767*	0.1583	0.9024*	0.8908*	0.9459*	0.8634*	0.8845*	1.0000
	0.0708	0.1303	0.0010	0.0000	0.0000	0.5051	0.0000	0.0000	0.0000	0.0000	0.0000	
td	0.2771	0.3183	0.5849*	0.8036*	0.8005*	0.0900	0.8615*	0.8626*	0.9148*	0.8621*	0.8010*	0.9100*
	0.2368	0.1714	0.0068	0.0000	0.0000	0.7058	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
td1	0.2771	0.3183	0.5849*	0.8036*	0.8005*	0.0900	0.8615*	0.8626*	0.9148*	0.8621*	0.8010*	0.9100*
	0.2368	0.1714	0.0068	0.0000	0.0000	0.7058	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
pc	0.3634	0.3536	0.6190*	0.8756*	0.8276*	0.0863	0.9030*	0.9013*	0.9747*	0.8657*	0.8836*	0.9714*
	0.1153	0.1262	0.0036	0.0000	0.0000	0.7175	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
nfs	0.2887	0.4048	0.7012*	0.8950*	0.8390*	0.0282	0.9127*	0.9063*	0.8451*	0.8941*	0.9646*	0.8996*
	0.2170	0.0767	0.0006	0.0000	0.0000	0.9060	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
nufs	-0.3420	-0.5774*	-0.5733*	-0.6243*	-0.6757*	-0.1409	-0.6039*	-0.5907*	-0.6702*	-0.5802*	-0.5599*	-0.6366*
	0.1400	0.0077	0.0082	0.0033	0.0011	0.5534	0.0048	0.0061	0.0012	0.0073	0.0102	0.0025

	td	td1	pc	nfs	nufs
td	1.0000				
td1	1.0000*	1.0000			
	0.0000				

Table 4.4: The relationship between yield, Al (Awn length) and NFS(Number of Fertile Spikelets)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1080.719	261.930		-4.126	.001
	AL	13.415	5.358	.438	2.503	.023
	NFS	83.445	27.029	.541	3.087	.007

a. Dependent Variable: Yield

Yield= -1080.719+13.415(AL)+83.445(NFS)

After adjusting for AL yield will increase by 83.45 units for every unit increase in NFS. After adjusting for NFS yield will increase by 13.415 units for every unit increase in AL. If number of fertile spikelets and awn length once known, they can be used to estimate yield.

CHAPTER 5

DISCUSSIONS

5.1 Growth performance of summer wheat varieties under wetlands

Sahai showed significantly shortest days to anthesis and maturity. Its low yield can be attributed to shorter period taken during grain filling. Aguilal, the highest yielding variety showed significantly longest days to reach anthesis and to maturity. This means it had the longest period for grain filling. Long grain fill periods lead to increased accumulation of dry weight in the seed. This was also supported by significant positive correlations between days to maturity with grain yield and yield influencing traits. These results are in agreement with Kumar *et al.*, (2000), Esmail (2003) and Singh *et al.*, (2006).Aguilal the highest yielding variety also had significantly longest spikes and awns. This also contributed to its high yield. Spike length and awn length showed significant positive correlation with grain yield and yield influencing traits.(Sokoto *et al.*, 2012) observed that photosynthesis in the awns provide 10 to 20% of grain weight. Summer wheat varieties which take longer days to mature and have longer spikes and awns can be recommended basing on results of this study.

5.2Performance of summer wheat varieties for grain yield and its components when grown under wetlands conditions.

There were significant differences in the grain yield of the varieties under study. Aguilal was the highest yielding variety which produced 1.64 t/ha. This could be due to longer spike and awn length, increased number of spikelets per spike, higher number of grains per spike and the ability to produce more tillers. Correlation analysis showed highest positive significant correlation between number of spikelets and number of fertile spikelets per spike. Spike length and number of grains per spike also showed positive significant correlation with yield. This is in agreement with Saha and Abi-antaum (1998) who observed that grain number, grain size and fertility are the most contributing yield factors. (Sheron *et al.*, 1986) observed that spike length and grain per spike were directly related to grain yield. Utique produced 1.45t/ha, Quafzah 1.44 t/ha, Reyna 1.38 t/ha. The least was Sahai which produced 0.88 t/ha. In Ethiopia Aguilal produced an average of 3.2 t/ha this shows a reduction in yield of 49%. This can be attributed to the Elnino induced drought experienced during the 2015/2016 season. (Kilic and Yagbasanlar, 2010) observed that average yield reduction due to drought conditions were 61.4% in an experiment conducted to compare yield under well watered and drought conditions in wheat.

The average yield for wetland winter wheat for ward 11 for the past 5 years was 0.5 t/ha dropping from 1.5-2 t/ha (crop assessment database 2016). This can be attributed to change of rainfall patterns. Summer wheat can therefore be recommended in ward 11 as an alternative production method.

5.3Disease incidence and severity of summer wheat varieties grown in wetlands.

The study also aimed at evaluating disease incidence and severity of leaf and stem rust on the different exotic summer wheat varieties. There was no significant difference on leaf and stem rust incidence and severity. All the varieties scored 0 which according to McNeal *et al* (1971) rust scoring guide indicates Immune to leaf and stem rust. The implication is this could mean a success in breeding of summer wheat varieties. It could also be due to the unavailability of conditions which favour disease establishment i.e moisture. Carrying out the experiment for more than one season will give better results on leaf and stem rust.

5.4 Quality of summer wheat varieties grown in wetlands condition

The quality of the summer wheat varieties was also evaluated. There were significant differences in test density. Aguilal had a test density of 81.35 Kg/hl. Test density which is greater than 75 kg/hl is the desired. Quafzah and Reyna had 78.05 kg/hl and 78.70 kg/hl respectively. Reyna and Sahai produced less than the standard. Reyna had 74.20 kg/hl whilst Sahai had 67 kg/hl. Test density is influenced by maturity of wheat, kernel density and variety of wheat. Aguilal had the longest awns which contribute to head photosynthesis and grain weight. This factor contributed to its highest test density. This was also supported by correlation analysis were a highly significant correlation is observed between grain yield and quality.

There was no significant difference in protein content during separation of means. Protein content which is >11% is required in bread making. All the exotic varieties had protein content greater than 11%. Only Sahai failed to meet the standard. This implies that summer wheat has the quality needed for bread making therefore it can be used to compliment winter stocks.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The study showed that the exotic varieties performed better than the local variety in terms of yield and quality. Summer wheat therefore can compliment winter wheat as production costs are lower. With land reform programme the number of small scale farmers has increased therefore their contribution can no longer be ignored or treated as insignificant. There was a significant difference between summer wheat varieties on growth performance. Exotic summer wheat varieties had good growth performance.

The study showed that all the varieties were immune to leaf and stem rust. It can therefore be concluded that late summer wheat has low risk of leaf and stem rust.

The exotic varieties had better quality, all had protein content higher than 11% and three had test density greater than 75 kg/hl.

6.2 Recommendations

Areas of further study can be focused on evaluation of more summer wheat varieties; only four exotic varieties were evaluated. More diseases can also be evaluated for example Powdery mildew which favour moist conditions experienced in summer to establish. Analysis on wheat quality can also be furthered for example amount of gluten. One trial was also carried out. There is the need to increase more sites in future experiments for better results. Carrying out the study for more than one season is also important as it caters for differences in seasons thereby giving better results.

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APPENDICES

Appendix1. Accumulated analysis of variance for evaluation of days to Anthesis

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	27.3500	9.1167	9.60	
REP.*Units* stratum					
TRT	4	281.8000	70.4500	74.16	<.001
Residual	12	11.4000	0.9500		
Total	19	320.5500			

Appendix2. Accumulated analysis of variance for evaluation of days to maturity

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	125.0000	41.6667	250.00	
REP.*Units* stratum					
TRT	4	482.0000	120.5000	723.00	<.001
Residual	12	2.0000	0.1667		
Total	19	609.0000			

Appendix 3. Accumulated analysis of variance for evaluation of final plant height

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	9.7500	3.2500	8.67	
REP.*Units* stratum					
TRT	4	434.3000	108.5750	289.53	<.001
Residual	12	4.5000	0.3750		
Total	19	448.5500			

Appendix4. Accumulated analysis of variance for evaluation of spike length

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	391.200	130.400	18.79	
REP.*Units* stratum					
TRT	4	1270.700	317.675	45.76	<.001
Residual	12	83.300	6.942		
Total	19	1745.200			

Appendix5. Accumulated analysis of variance for evaluation of awn length

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Rep stratum	3	6.5500	2.1833	3.01	
Rep.*Units* stratum					
TRT	4	1404.5000	351.1250	484.31	<.001
Residual	12	8.7000	0.7250		
Total	19	1419.7500			

Appendix 6. Accumulated analysis of variance for evaluation of number of tillers per plant

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	0.0000	0.0000		
REP.*Units* stratum					
TRT	4	44.8000	11.2000		
Residual	12	0.0000	0.0000		
Total	19	44.8000			

Appendix 7. Accumulated analysis of variance for evaluation of number spikelets per spike

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	0.5500	0.1833	1.29	
REP.*Units* stratum					
TRT	4	36.3000	9.0750	64.06	<.001
Residual	12	1.7000	0.1417		
Total	19	38.5500			

Appendix 8. Accumulated analysis of variance for evaluation of number of fertile spikelets per spike

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	1.0000	0.3333	1.33	
REP.*Units* stratum					
TRT	4	51.8000	12.9500	51.80	<.001
Residual	12	3.0000	0.2500		
Total	19	55.8000			

Appendix 9. Accumulated analysis of variance for evaluation of number of unfertile spikelets per spike

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Rep stratum	3	0.06986	0.02329	1.83	
Rep.*Units* stratum					
TRT	4	0.25403	0.06351	5.00	0.013
Residual	12	0.15242	0.01270		
Total	19	0.47631			

Appendix10. Accumulated analysis of variance for evaluation of grains per spike

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	0.5500	0.1833	0.81	
REP.*Units* stratum					
TRT	4	243.7000	60.9250	270.78	<.001
Residual	12	2.7000	0.2250		
Total	19	246.9500			

Appendix 11. Accumulated analysis of variance for evaluation of grain yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	0.009894	0.003298	1.12	
REP.*Units* stratum					
TRT	4	1.284001	0.321000	108.83	<.001
Residual	12	0.035395	0.002950		
Total	19	1.329290			

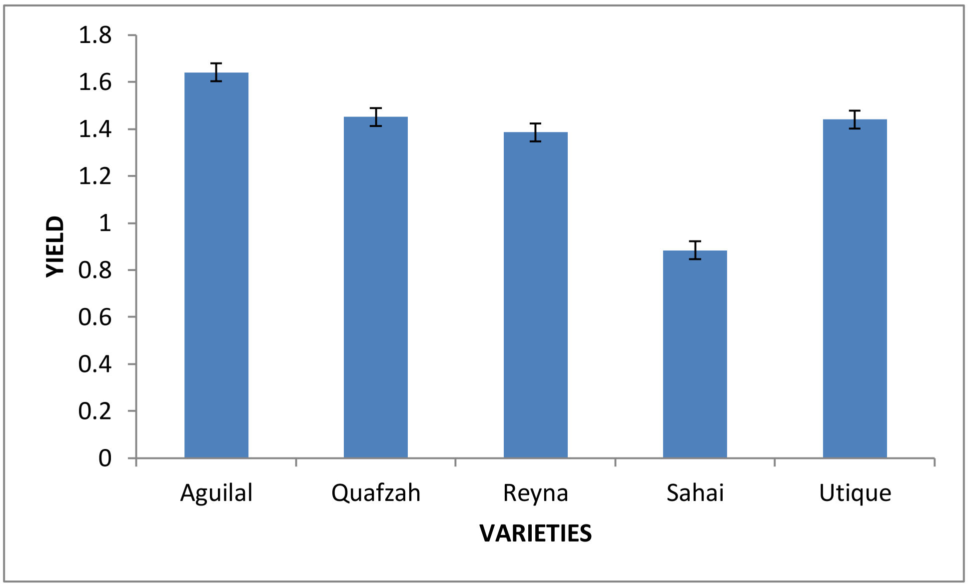
Appendix 12. Accumulated analysis of variance for evaluation of protein content

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	0.0000	0.0000		
REP.*Units* stratum					
TRT	4	20.0480	5.0120		
Residual	12	0.0000	0.0000		
Total	19	20.0480			

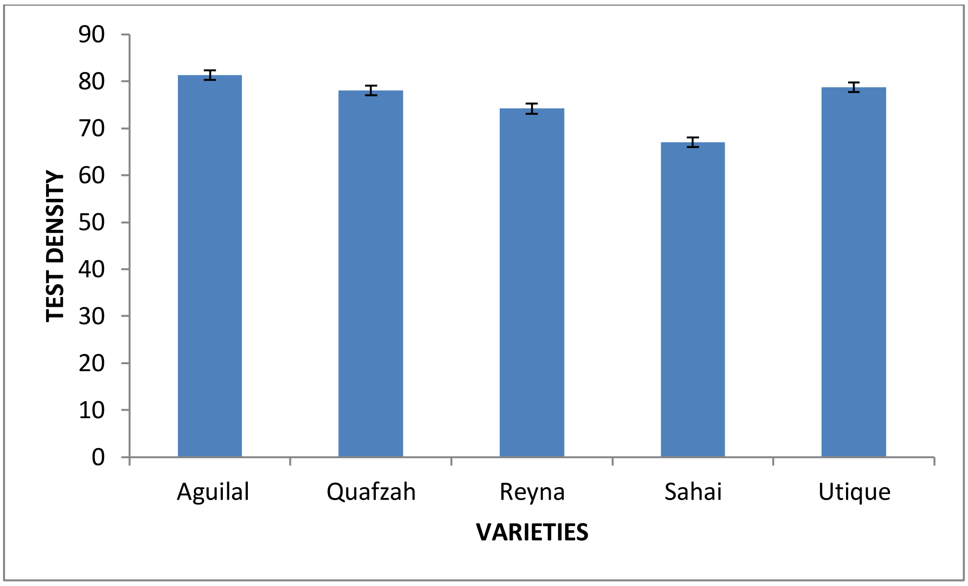
Appendix 13. Accumulated analysis of variance for evaluation of test density

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
REP stratum	3	7.128	2.376	1.07	
REP.*Units* stratum					
TRT	4	497.028	124.257	56.11	<.001
Residual	12	26.572	2.214		
Total	19	530.728			

APPENDIX 14: GRAIN YIELD OF SUMMER WHEAT VARIETIES



APPENDIX 15: TEST DENSITY OF SUMMER WHEAT VARIETIES



Appendix 16 Multivariate analyisis

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.960[a]	.922	.913	78.192

a. Predictors: (Constant), NFS, AL

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1224978.094	2	612489.047	100.178	.000[b]
	Residual	103938.456	17	6114.027		
	Total	1328916.550	19			

a. Dependent Variable: Yield

b. Predictors: (Constant), NFS, AL