

# Evaluation of Elite Bread Wheat Selections from the CIMMYT for Crop Production

Ibrahim Naser<sup>\*,1</sup>, Emiliano Olbinado<sup>1</sup>, Abu Kashem Abdul Hakeem<sup>2</sup>

<sup>1</sup>Previous Address: Research Dept., TADCO, Tabuk 71421, P O Box 808, Saudi Arabia

<sup>2</sup>Present Address: Laboratory Unit, TADCO, Tabuk 71421, P O Box 808, Saudi Arabia

\*Present Address: Marj Al-Hammam, Amman, Jordan

## ABSTRACT

Two years field trials on 29 bread wheat entries/varieties of the 3<sup>rd</sup> Elite Bread Wheat from the CIMMYT along with Yecora Rojo variety were conducted in 2008 – 2010. Productivity of the entries in 2008 season ranged 6.77 – 9.6 M.T.; the yield of Yecora Rojo ranked 7<sup>th</sup> with 8.19 M.T. /Ha. Test harvest on ten selected entries/varieties in 2009 season ranged 9.32 – 10.02 M.T. /Ha. Increased productivity in 2009 season was mainly due to mild weather during the grains filling period. Production increase lead to less %crude protein in the grains and the flour samples, but %starch in the grains was increased. Zeleny number which measures the quality and quantity of the grains gluten was less than in 2008, but still high with value 51.67.

Field tests & Lab tests showed four entries/varieties of high quality and high productivity # 19, 24, 11 and 25; also two entries/varieties of high productivity # 27, 29 and two entries/varieties of high quality # 4 and 8. The selected entries/varieties shown promising results towards the development of new varieties suitable for the end user.

Summary descriptions of the top three entries/varieties were: Entry # 19: height 82.2 cm, maturity 145 days, grains color light red, protein 14.02%, Zeleny number 55.32, %wet gluten 34.68, %ash 1.03, %water absorption 61.97, high yield and high quality. Entry # 24: height 87.7 cm, maturity 145 days, grains color white, protein 14.02%, Zeleny number 53.46, %wet gluten 32.16, %ash 1.11, %water absorption 62.0, high yield and high quality. Entry # 11: height 94.2 cm, maturity 145 days, grains color light red, protein 13.28%, Zeleny number 49.88, %wet gluten 30.16, %ash 1.13, %water absorption 62.07, high yield and high Quality.

**Keywords:** Bread Wheat, %Crude Protein, %Wheat Starch, Zeleny Number, Grain & Flour Analyzer

## I. INTRODUCTION

Wheat crop is an important crop worldwide as it provides more nourishment for humans more than any other food crop [1]. Due to increased demand for wheat commodity to satisfy the increased population in Saudi Arabia, they put plans by the end of 1977 to expand growing this crop under Centre pivot irrigation system to reach self-sufficiency in the production of this crop. After testing different bread wheat varieties including Pro-bread, West-bread and Yecora Rojo,

the Saudi farmers chose Yecora Rojo which became the dominant bread wheat variety grown under Centre pivot irrigation system in all agricultural areas in this country [2].

As per TADCO strategy plans to test new varieties of bread wheat of high productivity and promising technological characters, the company tested during the period 2000 - 2011 different bread wheat varieties in coordination with the Seeds Producers Committee (SPC) and the Saudi Ministry of Agriculture (MOA) in Riyadh to get new varieties of desired quality by the end user. For this purpose, TADCO research unit tested in 2001/2002 cropping seasons eight American bread wheat varieties under code numbers 81470 to 81477 in addition of five hard white bread wheat varieties from the MOA: Tia, Kauz, Irena, Parus, HD-2329. In 2004 – 2006, the company conducted three years field trials on four Australian wheat varieties for the purpose of processing good quality bread, hard pastry and noodles [3]. No final agreement with the Australian seeds companies was materialized to localize the cultivation of the selected varieties. So, TADCO directed their research unit towards investigating new varieties/entries from the CIMMYT under the name 3<sup>rd</sup> Elite bread wheat (3rdEBW). The research unit conducted trials in 2008 and 2009 cropping seasons on 29 elite bread wheat selections [4]. The seeds samples brought from the CIMMYT nurseries to TADCO on January 13, 2008 through the Research Department of the Ministry of Agriculture in Riyadh, Saudi Arabia.

This article is a review of research work carried out at TADCO by the authors on 29 wheat entries/varieties in addition of the local variety Yecora Rojo during the period 2008 – 2010. The purpose of this study was to conduct field trials on these entries/varieties to choose out of them varieties of high productivity with high quality.

## II. MATERIALS & METHODS

**Land Preparation:** Pre-irrigation of the trials area for two rounds of irrigation was carried at a speed of 20% with a total amount of 45 – 50 mm, then wait for two weeks to encourage weeds germination then irrigate two rounds of total 12 mm. Plow the soil when it reached proper moisture conditions by cross chisel plow at a depth of 30 cm in the opposite direction (45° angle), then one pass of pipe levelling. Broadcast granular fertilizer 14-38-10 at the trial area at a rate of 280 kg/Ha before sowing the seeds then



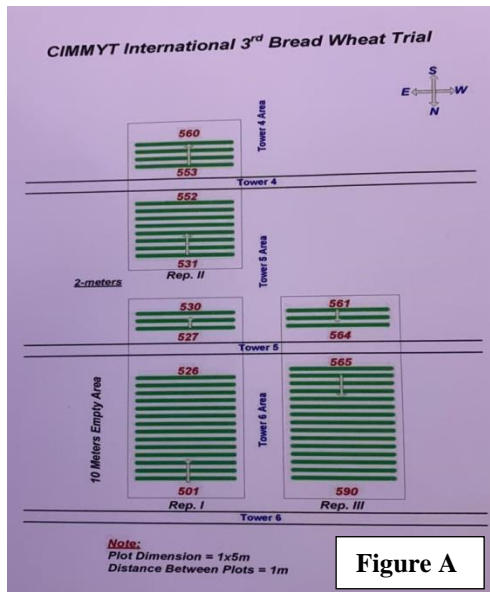
mixing the fertilizer into the soil surface with shallow disking before sowing the seeds.

**Trials Layout:** Two wheat field trials were conducted: The first trial was conducted on January 21, 2008 relatively late due to delay in receiving the seeds samples from the supplier. This trial included 29 entries/varieties in addition to the local variety Yecora Rojo as control, the trial was arranged into a randomized complete block design (RCBD) [4]. Each entry/variety was arranged into three replicated plots, each plot was five meter length and one meter width with an area of 5 M<sup>2</sup>/plot, and the planted area of each entry was 15 M<sup>2</sup>. One meter was left between each plot, and three meters between the blocks, and the total number of plots was 90, see **Figure 1A**. The seeds of each entry were sown manually into the corresponding plot and arranged into five rows at 20 cm distance and at a depth of sowing 2-3 cm. The seeds were manually covered by hand rake, and one round of light irrigation at low pressure 10- 15 psi was carried out on daily bases until germination was started.

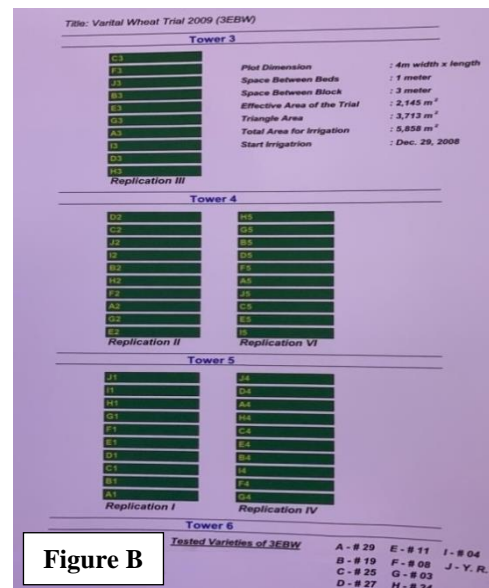
The second trial was conducted on December 29, 2008, and the seeds source was from the harvest of 2008 wheat trial. The trial consisted 9 entries/varieties which shown promising yield and quality in addition to Yecora Rojo; the trial was arranged into a randomized complete block design (RCBD). Each entry/variety was arranged into five replicated plots; each plot was five meter length and four meter width with an area of 20 M<sup>2</sup>/plot. One meter was left between each plot, and three meters was left between the blocks; the total number of plots was 50, see **Figure 1B**. The seeds were broadcasted manually into the corresponding plots then covered manually by hand rake. One round of light irrigation At low pressure 10 – 15 psi was carried out on daily bases until germination was started.

**Crop Maintenance:** Daily activities for crop maintenance was carried out by research personnel and involved irrigation of 9 – 12 mm / day during the hottest period of the weeks and in winter months irrigation was scheduled for one day on and one day off; intervals were dependent on the soil moisture. Injection of soluble fertilizers as per the crop needs, Broadleaves weeds and grasses infestations were controlled at the 3-5 leaves stage by spraying mixture of herbicides Shaheen 10 gram + Bromoxynil 150 ml/100 liter of water 40 days after sowing.

**Trials Methods and Data Recording:** To compare the different entries/cultivars with each other and with the control variety Yecora Rojo: research personnel were directed to monitor each trial during the growing season and collect grains samples after harvest to study the agronomic and quality characters of the varieties. For the agronomic characters they recorded the following data: number of plants/M<sup>2</sup>, number of tillers/plant, spike length, Plants height, number of seeds/spike, number of days for 100% heading, date of maturity, 1000 grains weight (TGW) & estimation of cultivars productivity M.T./Ha., disease incidence, resistance to lodging, resistance to shattering, %black point. For the quality characters of the entries/varieties, grain samples of each entry of each season, each 2 kg were collected and sent to the laboratory for grains and flour analysis. Each sample was analyzed using Grain Analyzer Infratec 1241 for the following tests: test weight, %crude protein, %moisture content, %starch, %wet gluten, Zeleny test [5], and manually conducted TGW, %black point. Another part of the grains sample of each entry was milled to get flour sample and conduct the following tests: %crude protein, %moisture content, %ash, %wet gluten and %water absorption.



**Figure A**



**Figure B**

**Figure 1. A- Layout of 29 bread wheat entries/varieties + Yecora Rojo as control for the 2008 field trial. B- Layout of ten selected bread wheat entries/varieties for the 2009 field trial.**

Before the final harvest of 2008 trial, test harvest was conducted by harvesting representative samples; each sample is one square meter taken from two spots in each plot. To compare the entries/varieties with each other, the 5M<sup>2</sup> plots of 2008 trial were manually harvested by the 1<sup>st</sup> of June 2008, and kept separately into labelled jute bags, then threshing the wheat straw of each bag, cleaned the grains and kept them into labelled plastic bags for further analysis. The harvest of 2009 trial was carried out by 1<sup>st</sup> of June 2009. Due to the shortage of time and unavailability of labors for manual harvest of this trial, we conducted test harvest on this trial in a similar manner of 2008 test harvest. The harvested samples were processed for further analysis in a similar manner of 2008 trial. Then we recorded the productivity of each entry/variety as Kg/M<sup>2</sup>.

Statistical analysis for the productivity of the wheat entries/varieties was carried out using Statistics10 to measure the significance difference between the wheat entries.

### III. RESULTS & DISCUSSION

#### Observations on the 2008 field wheat trial:

**A1- Agronomic Characters** [3]: The results on the agronomic characters of the 30 entries/varieties in the 2008 cropping season are presented in **Table 1** and **Figure 2**, we observed the following:

**1- Plant height:** All of the varieties were relatively short and ranged 64.63 – 94.60 cm; Yecora Rojo was the shortest with 64.63 cm followed in ascending order the entries # 19, 18, 5 and 6 with 76.53, 81.60, 82.93, 82.97 centimeter respectively. It is desired to get a dwarf variety to overcome lodging problem.

**2- Number of days for 100% heading:** It is desired to get an early heading variety to escape hot weather during the grains filling period, and it ranged 85 – 94 days. We observed the earliest entry/variety reaching 100% heading in ascending order was entry # 20, 27, 21, 10, 17, 19 with 85, 86, 87, 88, 88, 88 days respectively, and these entries were earlier than Yecora Rojo which reached 90 days.

**3- Number of days for maturity:** It is desired to get an early maturing variety to save energy & water, and it ranged 119 – 126 days. We observed the earliest maturing variety in ascending order was entry # 20, 21, 22, 12, 6, 9, with 119, 120, 120, 121, 121, 121 days respectively; Yecora Rojo was with 121 days.

**4- Length of spike:** Increased spike length leads to more seeds/spike as it is an indicator for higher yield, and it ranged 10.38 – 13.63 cm. We observed the following entries in descending order with long spikes: # 17, 15, 14, 28, 23, 25 with 13.63, 13.36, 13.29, 13.17, 12.96, 12.93 cm respectively; Yecora Rojo was with 11.23 cm.

**5- Number of spikes/ M<sup>2</sup>:** It is an important parameter affecting the potential yield of a particular variety as it is desired to get a variety with more spikes / M<sup>2</sup>, and it ranged 446 – 694 spikes. We observed the following entries in ascending order for more spikes / M<sup>2</sup>: # 5, 2, 4, 28, 27 with 446, 513, 526, 531, 532 spikes, and the highest was entry # 18 with 694 spikes; Yecora Rojo was with 625 spikes/M<sup>2</sup>.

**6- Number of seeds/Spike:** It is an important parameter affecting the potential yield of a particular variety, and it ranged 56 – 71 seeds/spike. We observed the number of seeds per spikes in ascending order the entries # 6, 9, 7, 21, 8 with 56, 56, 57, 57, 59 respectively and the highest was entry # 29 with 71 seeds/spikes; Yecora Rojo was with 56 seeds/spike

**7- Specific Weight:** It is an important parameter affecting the potential yield of a particular variety; it was carried out by the grain analyzer, and it is expressed as test weight kg/hl and it ranged 79.37 – 84.20 gram/hl. We observed the highest specific weight on the following entries in descending order: # 29, 17, 30, 10, 13 with test weight 84.20, 84.00, 83.67, 82.67, 82.47 kg/hl; Yecora Rojo was with 81.40 kg/hl.

**7- One Thousand Grains weight (TGW):** This is another measure of specific weight which was carried out manually, and expressed as weight in grams per 1000 grains. The results shown TGW ranged 38.74 – 49.48 grams/1000 grains which was very high. We observed high TGW value on the following entries/varieties in descending order # 3, 2, 17, 14, 25 and Yecora Rojo with 49.48, 48.05, 46.92, 46.86, 46.64, 46.58 grams respectively. Increased TGW indicates good grains quality.

**9- % Black Point:** It is defined as the black color on the embryo tip of the wheat grains due to late irrigation of the wheat crop, and it ranged 0.09 – 0.58 %. We observed the %black point in ascending order on the entries # 9, 11, 28, 8, 29, 15 was 0.08, 0.1, 0.1, 0.12, 0.13, 0.14 respectively; Yecora Rojo was the lowest with 0.08%.

No serious wheat disease such as rusts, smuts, Septoria etc. was observed on the third elite bread wheat (3<sup>rd</sup> EBW) entries/varieties during the trials period.

**B1- Productivity** [3]: Data on the mean productivity of each entry/variety Kg/M<sup>2</sup> shown in **Table. 1** was calculated as metric ton per hectare. Entry # 29 produced the highest yield as it reached 9.6 M.T. /Ha followed by entry # 19 with 9.13 M.T./Ha then entry # 25 with 8.73 M.T./Ha then entry # 11 with 8.65 M.T./Ha then entry # 27 with 8.47 M.T./Ha ; Yecora Rojo rank 7th with productivity 8.19 M.T./Ha. The lowest productivity was 6.77 M.T. /Ha for entry # 2, see **Figure 3**. Productivity of entry # 29 was the highest due to high number of spikes/M<sup>2</sup> which reached around 672 spikes

**Table 1. Summary for the agronomic characters of the 3<sup>rd</sup> EBW entries/varieties in 2008 cropping season.**

Entry Number	Area (M <sup>2</sup> )	Plant Height in cm.	No. of Days at 100% Heading	No. of Days for Maturity	Spike length in cm.	No. of Spikes per M <sup>2</sup>	No. of Seeds per Spike	TG W	Specific Weight Kg/HL	Production Kg/5 M <sup>2</sup>	Yield M.T./Ha	Potential Yield M.T./Ha.	%Black Point by Weight
Y. R.*	15	64.6	90	121	11.2	625	55.6	41.8	81.4	12.3	8.2	9.5	0.08
2	15	87.3	92	126	11.2	513	66.6	48.1	81.0	10.2	6.8	8.0	0.91
3	15	85.1	91	123	10.7	607	66.3	49.5	80.1	10.2	6.8	8.4	0.56
4	15	89.4	91	124	10.9	526	66.2	46.5	80.1	11.1	7.4	8.7	0.49
5	15	82.9	92	125	11.5	446	68.9	44.9	79.4	11.0	7.3	8.8	0.16
6	15	83.0	91	121	10.8	578	55.6	42.3	82.4	11.6	7.8	9.2	0.18
7	15	92.4	89	124	12.1	564	57.2	48.6	83.1	11.3	7.5	9.2	0.32
8	15	90.0	89	123	10.3	631	58.8	44.2	82.0	11.2	7.5	9.2	0.12
9	15	64.6	90	121	11.2	625	55.6	41.8	81.4	12.3	8.2	9.5	0.09
10	15	86.1	88	124	10.6	599	66.4	44.1	82.7	12.2	8.1	9.2	0.26
11	15	90.8	89	124	11.4	655	63.0	44.1	80.6	13.0	8.7	9.7	0.10
12	15	83.4	89	121	10.4	672	60.9	43.6	81.9	11.6	7.7	8.8	0.15
13	15	95.7	93	125	12.8	592	60.3	46.4	82.5	11.1	7.4	8.7	0.39
14	15	93.9	94	127	13.3	532	63.4	46.9	81.7	11.9	7.9	9.1	0.50
15	15	92.7	94	125	13.4	589	67.2	45.1	82.2	11.7	7.8	8.8	0.14
16	15	92.1	92	125	13.0	607	63.7	43.1	81.5	12.1	8.0	9.3	0.53
17	15	86.3	88	121	13.6	510	70.9	46.9	84.0	12.1	8.1	10.0	0.31
18	15	81.6	90	126	11.7	694	69.6	40.5	81.3	11.0	7.3	8.8	0.22
19	15	76.5	88	121	11.7	630	66.9	39.1	81.9	13.7	9.1	10.6	0.16
20	15	85.0	85	119	10.9	666	61.1	43.5	82.1	11.6	7.8	9.5	0.13
21	15	85.5	87	120	11.0	636	56.6	40.9	79.7	11.3	7.5	9.6	0.50
22	15	94.5	90	120	12.8	623	58.7	47.1	81.6	12.4	8.3	10.3	0.43
23	15	90.1	89	124	13.0	570	66.3	49.6	82.2	12.0	8.0	10.4	0.58
24	15	85.9	91	123	12.6	657	59.6	38.7	81.8	12.1	8.1	9.1	0.47
25	15	92.6	89	125	12.9	590	61.5	46.6	82.5	13.1	8.7	9.5	0.28



26	15	86.7	91	123	11.6	596	66.2	43.9	81.7	12.7	8.5	9.2	0.16
27	15	88.1	86	123	11.6	532	68.8	47.5	82.1	12.7	8.5	9.7	0.19
28	15	87.5	93	124	13.2	531	69.4	45.5	82.0	11.2	7.5	9.2	0.10
29	15	94.6	90	124	10.9	672	63.9	41.4	84.2	14.4	9.6	10.5	0.13
30	15	84.5	91	123	13.9	571	71.1	46.6	83.7	11.7	7.8	8.5	0.23

\* Y. R.: Yecora Rojo



Figure 2, Different wheat plants plots of the entries/varieties of the 3<sup>rd</sup> EBW on April 11, 2008.

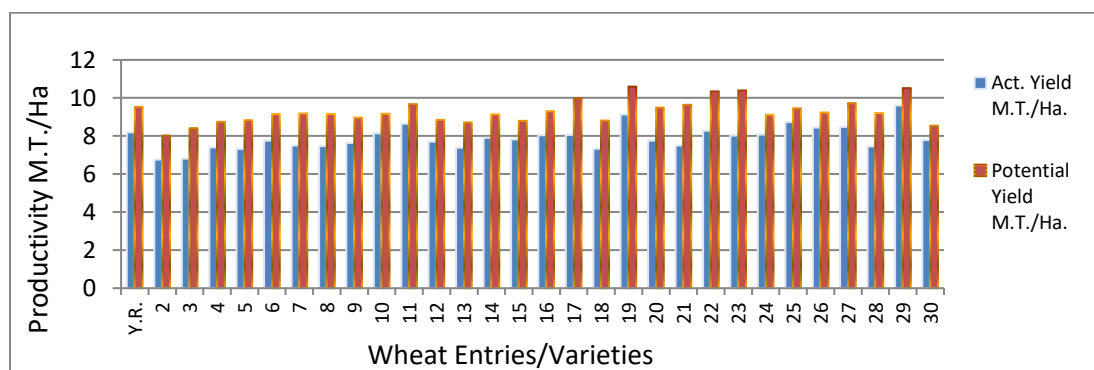


Figure 3, Actual yield and potential yield of the 3<sup>rd</sup> EBW entries/varieties in 2008 cropping season

per M<sup>2</sup> and high test weight which reached 84.20 Kg/hl. The potential yield of each entry/variety was estimated from the agronomic data as M.T. /Ha; and it is the product of the number spikes/M<sup>2</sup> multiplied by the number of grains in the spike times the weight of one thousand grains (grams) divided by 100000.

Entry # 19 shown high yield potential under favorable growing conditions as the estimated value reached 10.59

M.T./Ha followed by entry # 29 with 10.51 M.T./Ha then entry # 23 with estimated value 10.39 M.T./Ha then entry # 22 with estimated value 10.34 M.T./Ha. In comparison the potential yield for Yecora Rojo was 9.52 M.T. /Ha.

Statistical analysis for productivity kg/5M<sup>2</sup> shown no significant difference between the different entries due to low number of replicates in the trial. However differences as

percentages shown the productivity of entry # 29 was higher than Yecora Rojo by %17.22. Also Yecora Rojo productivity was higher by %17.40 than the lowest productivity of entry # 2.

The following illustrate the detailed statistical analysis for the entries productivity in 2008 trial as kg/5M<sup>2</sup>:

Randomized Complete Block AOV Table for Yield kg/5M<sup>2</sup>

Source	DF	SS	MS	F	P
Blocks	2	6.3372	3.16858		
Variety	29	8.3862	0.28918	0.87	0.6536
Error	58	19.3048	0.33284		
Total	89				

Grand Mean 3.9518 CV 14.60

Relative Efficiency, RCB 1.19

Means Yield for each entry Kg/5M<sup>2</sup>

Variety	Mean	Variety	Mean	Variety	Mean
Y.R.	4.0933	11	4.3233	21	3.7500
2	3.3833	12	3.8533	22	4.1367
3	3.4033	13	3.6933	23	4.0100
4	3.7000	14	3.9500	24	4.0367
5	3.6533	15	3.9100	25	4.3667
6	3.8733	16	4.0200	26	4.2233
7	3.7567	17	4.0300	27	4.2367
8	3.7367	18	3.6633	28	3.7233
9	3.8200	19	4.5633	29	4.8000
10	4.0700	20	3.8767	30	3.8967

Observations per Mean 3

Standard Error of a Mean 0.3331

Std Error (Diff of 2 Means) 0.4711

**C1- Grains Quality in 2008** [6], [7]:

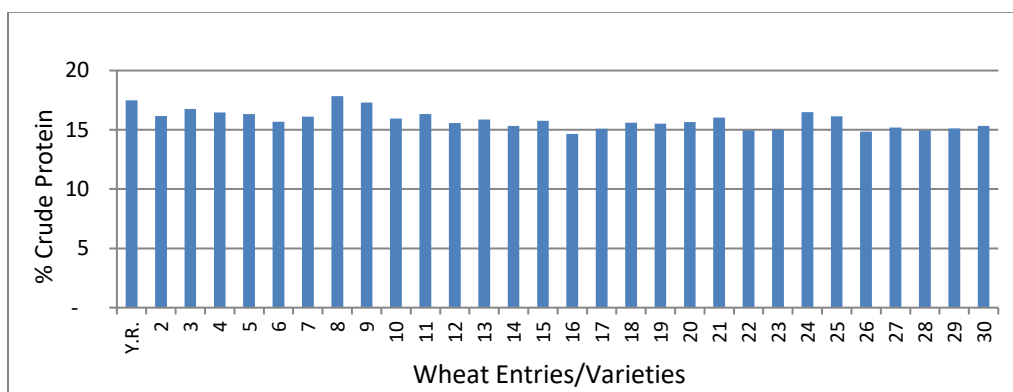
The results of the laboratory analysis on the grains samples

of 2008 field trial is presented in **Table 2**, the results had shown the following:

**1- % Crude Protein:** The percentage crude protein is dependent on genetic traits of the variety and the surrounding environment in the field, and it ranged 14.66 – 17.84%, see **Figure 4**. We observed that the grains samples of the entries # 8, 9, 3, 24 and 2 contained high percentage of crude protein in descending order as it reached 17.84, 17.30, 16.76, 16.48 and 16.17% respectively; Yecora Rojo was high as it reached 17.50%. Increased % crude protein was an indication of high grains quality of the 3<sup>rd</sup> EBW entries/varieties in 2008 cropping season.

**2- % Moisture Content:** The water content of the grains affects the degree of preservation during storage, and wheat grains with low moisture content (< 7%) show relatively higher values of grains components than those with higher values (11%). If the seeds moisture content was more than 14%, this leads to their infection with molds. The % moisture content ranged from 6.32 to 8.36% on all of the entries/varieties which was acceptable for seeds storage.

**3- % Starch:** Wheat grain contains 63 - 71% starch in the form of amylose and amylopectin. The percentage of starch has little effect on the functional properties of the flour, but mixing it with other ingredients of bread significantly affects the water absorption process and the fermentation time to make the dough as well as the structural characteristics of the bread crumbs and its dryness. The grains analysis results shown the % starch ranged from 60.50 to 64.60% which was relatively low on all of the varieties and this is normal for Tabuk area due to relatively high day temperature during the grain filling period; Yecora Rojo was with %starch content of 61.60.



**Figure 4, % Crude protein in the grains of the 3<sup>rd</sup> EBW entries/varieties in 2008 cropping season.**

**Table 2.** Laboratory analysis results on the grains samples of the 3<sup>rd</sup> EBW entries/varieties for 2008 cropping season.

Entry Number	%Crude Protein	%Moisture Content	%Starch	%Wet Gluten	Zeleny
Y.R*.	17.50	7.09	61.60	29.90	62.47
2	16.17	8.25	60.80	34.27	66.63
3	16.76	8.36	60.60	34.57	67.77
4	16.45	7.81	60.50	33.50	67.20
5	16.32	7.60	61.40	33.63	67.23
6	15.68	6.90	62.40	38.23	66.70
7	16.12	7.11	61.90	34.00	67.03
8	17.84	6.72	61.00	33.30	68.23
9	17.30	6.89	62.00	35.73	66.57
10	15.95	6.63	62.90	30.73	66.90
11	16.32	6.36	62.70	30.33	67.20
12	15.58	6.44	62.30	32.37	66.07
13	15.88	7.02	62.90	35.50	65.83
14	15.33	6.97	62.60	33.27	65.63
15	15.77	6.69	63.50	32.07	66.63

Entry Number	%Crude Protein	%Moisture Content	%Starch	%Wet Gluten	Zeleny
16	14.66	7.06	63.20	31.83	62.10
17	15.08	6.73	63.00	31.63	63.57
18	15.61	7.09	62.00	30.97	66.33
19	15.53	6.61	64.60	32.13	56.50
20	15.64	6.42	63.00	29.60	66.17
21	16.04	6.67	62.40	29.37	66.27
22	14.95	6.32	63.40	31.07	59.33
23	15.00	6.49	63.30	32.23	60.57
24	16.48	6.56	61.70	32.30	67.60
25	16.14	6.89	62.00	32.53	67.57
26	14.85	6.66	63.50	28.33	61.10
27	15.18	6.71	63.50	28.93	61.73
28	14.94	6.84	63.50	29.97	64.23
29	15.11	6.47	62.90	28.80	64.57
30	15.33	6.58	62.20	29.33	63.57

4- % Wet Gluten: Gluten is the name of wheat grains protein, and it ranged 28.33 – 38.23%. We observed that the grains samples of the entries/varieties # 6, 9, 13, 3, 2 and 7 contained high percentage of wet gluten in descending order as it reached 38.23, 35.73, 35.50, 34.57, 34.27, 34.00 % respectively; Yecora Rojo reached 29.60%. Increased % wet gluten is an indication of good grains quality.

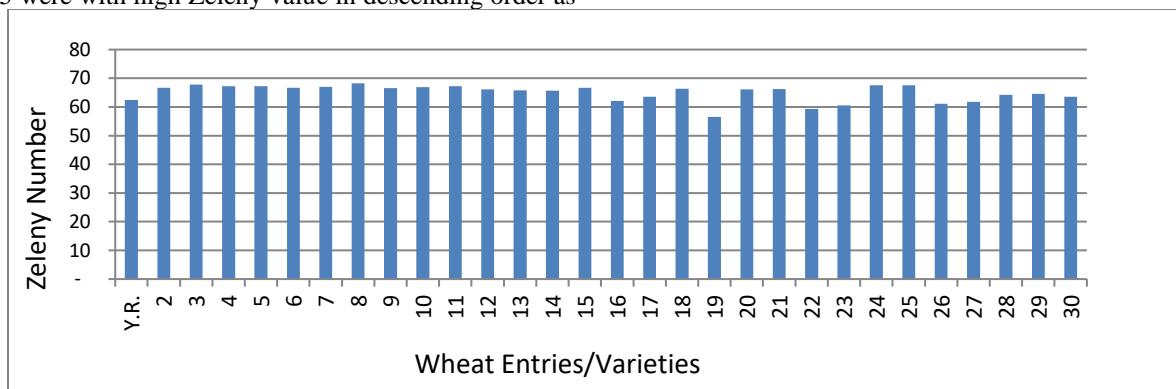
5- Zeleny Number [8]: This parameter measures the quality and quantity of gluten; the components of wheat gluten are glutenin and gliadin. High Zeleny value indicates an increase in the flour content of glutenin at the expense of gliadin, and thus indicates an increase in the dough strength. We observed that Zeleny value on the grains samples ranged 56.50 – 68.23, see **Figure 5**. The grains samples of the entries # 8, 3, 24, 25, 5 were with high Zeleny value in descending order as

they reached 68.23, 67.77, 67.60, 67.57 and 67.23 respectively; the Zeleny value of Yecora Rojo was 62.47. These results indicate excellent grains quality.

**D1- Flour Quality in 2008** [9], [10], [11]:

The results of the laboratory analysis on whole wheat flour samples after milling the grains samples of 2008 trial is presented in **Table 3**, the results had shown the following:

1- % Crude Protein: We observed the percentage protein content on the flour samples ranged 14.31 - 17.79%. The flour samples of the entries # 8, 3, 9, 5 contained high percentage of crude protein in descending order as they reached 17.79, 17.58, 16.99 and 16.69% respectively; Yecora contained the highest percentage of crude protein as it



**Figure 5.** Zeleny number on the grains of the 3<sup>rd</sup> EBW entries/varieties in 2008 cropping season.

**Table 3. Laboratory analysis results on the flour samples of the 3<sup>rd</sup> EBW entries/varieties for 2008 cropping season**

Entry number	%Crude Protein	%Moisture Content	%Ash	%Water Absorption	%Wet Gluten
Y.R.	17.86	6.39	1.22	62.44	59.43
2	16.63	6.77	1.25	62.56	49.26
3	17.58	6.95	1.23	62.54	51.13
4	16.66	6.54	1.23	62.48	46.39
5	16.69	6.24	1.14	62.63	49.02
6	15.88	6.05	1.18	62.50	39.75
7	16.55	6.22	1.10	62.58	50.05
8	17.79	6.11	1.18	62.63	59.21
9	16.99	5.97	1.11	62.57	55.74
10	15.58	5.89	1.04	62.60	43.13
11	16.70	5.80	1.13	62.60	46.38
12	16.09	6.07	1.13	62.54	46.80
13	14.90	6.43	1.10	62.46	40.19
14	15.46	6.36	1.13	62.52	41.73
15	14.97	5.90	1.12	62.35	38.03

Entry number	%Crude Protein	%Moisture Content	%Ash	%Water Absorption	%Wet Gluten
16	14.31	6.48	1.08	62.41	37.63
17	15.35	6.58	1.16	62.43	37.64
18	14.45	6.13	1.06	62.37	37.95
19	14.95	6.04	0.93	62.51	36.90
20	15.18	5.94	1.11	62.41	35.52
21	16.19	5.92	1.15	62.32	49.77
22	14.87	5.76	1.06	62.42	34.88
23	14.88	5.98	1.05	62.54	36.90
24	16.13	5.87	1.20	62.56	48.16
25	15.50	6.30	1.05	62.47	43.64
26	15.12	5.65	1.11	62.29	43.73
27	14.66	6.05	1.05	62.36	36.22
28	14.42	5.97	1.10	62.06	32.11
29	15.14	5.73	1.10	62.50	40.61
30	15.63	5.84	1.04	62.60	44.65

reached 17.86%. Increased % crude protein in the flour samples is an indication of high wheat flour quality.

**2- % Wet Gluten:** We observed that the percentage wet gluten on the flour samples ranged 32.11 – 59.21%. The flour samples of the entries # 8 ,9 ,3 ,7 , 21 contained high percentage of wet gluten in descending order as they reached 59.21, 55.74, 51.13, 50.05, 49.77% respectively; Yecora Rojo was the highest as it reached 59.43%. Increased % wet gluten is an indication of high flour quality, see **Figure 6**.

**3- % Moisture Content:** The percentage moisture content on the flour samples ranged 5.65 – 6.95% which is relatively very low, and it was acceptable for flour storage; the moisture content of Yecora Rojo flour was within that range with 6.39%. Low moisture content was due to dry grains at the time of harvest in summer.

**4- % Ash:** This represents the percentage of mineral elements in the flour. The percentage ash content on the flour samples ranged 0.93 – 1.25%, and the acceptable level for whole wheat flour is < 1.3%. We observed that the flour of the entries # 19, 10, 30, 23, 25 and 27 contained low level of ash in ascending order as it reached 0.93, 1.04, 1.04, 1.05, 1.05, 1.05 and 1.05% respectively; Yecora Rojo flour samples contained 1.22%. Low % Ash is desired in the wheat flour as the flour color appears whiter, while flour with high % Ash appears with less white color.

**5- % Water Absorption:** Water absorption in the different flour samples of the entries/varieties ranged from 62.06 – 62.63% and it was acceptable. Normal value for the relative water absorption in bread wheat flour range is 60 – 66%, and high value is desired in

bread wheat. Increased relative % water absorption of the flour is desired by the bakeries as it produces more bread quantity.

#### Observations on the 2009 field wheat trial:

**A2: Agronomic characters** [3]: Ten entries/varieties were selected in 2009 trial based on high productivity of entries/varieties # 29, 19, 25, 27, 11 and high quality of entries/varieties # 8, 3, 24, 4 of 2008 trial, and in addition Yecora Rojo as control. The results are presented in Table 4 and Figure 7, we observed the following:

**1- Plant height:** All of the varieties were relatively short and ranged 82.2 – 94.2 cm; Yecora Rojo was the shortest with 67.6 cm followed in ascending order of height by the entries 19, 27, 24, 29 with 82, 87.4, 87.7, 90 cm respectively; Entry # 11 was the highest with 94.2 cm.

**2- Number of days for 100% heading:** We observed Yecora Rojo was the earliest variety for 100% heading with 99.6 days followed in ascending order the entries # 25, 27, 8, 24 with 99.8, 100.2, 100.4, 100.4 days respectively. entry # 4 was the latest with 106.2 days.

**3- Number of days for maturity:** The number of days for maturity ranged 137– 146 days; Yecora Rojo was the earliest maturing variety with 137 days followed in ascending order for maturity entries/varieties # 25, 27, 8, 24, 29 and 19 with 139 , 140, 145, 145, 145 days respectively; entry # 4 was the latest with 146 days.

**4- Length of spike:** The spike length ranged 9.2 – 11.3 cm. We observed the following entries/varieties in descending order have long spikes # 25, 27, 24, 19 & 11 with 11.3, 10.8, 10.7, 10.7, 10.4 respectively; Yecora Rojo was with spike



length 9.6 cm.

**5- Number of spikes/M<sup>2</sup>:** The number of spikes/M<sup>2</sup> ranged 556 – 657. We observed the following entries in descending order for more spikes / M<sup>2</sup>: # 29, 11, 24, 4, 8, 3 with 657, 633, 633, 622, 619, 617 respectively; Yecora Rojo was with 591 spike/ M<sup>2</sup>.

**6- Number of seeds/spike:** We observed that the highest number of seeds per spike in descending order the

entries/varieties # 27, 24, 4, 19 then Yecora Rojo with 70, 64, 63, 62 respectively.

**7- Specific Weight (Kg/hl):** We observed the highest specific weight on the following entries/varieties in descending order: # 29, 8, 24, Y.R., 27 and 25 with 83.68, 83.24, 83, 16, 82.68, 82.64, 82.44 kg/hl respectively. Increased test weight indicates good grains quality.

**8- One Thousand Grains weight (TGW):** The results in 2009

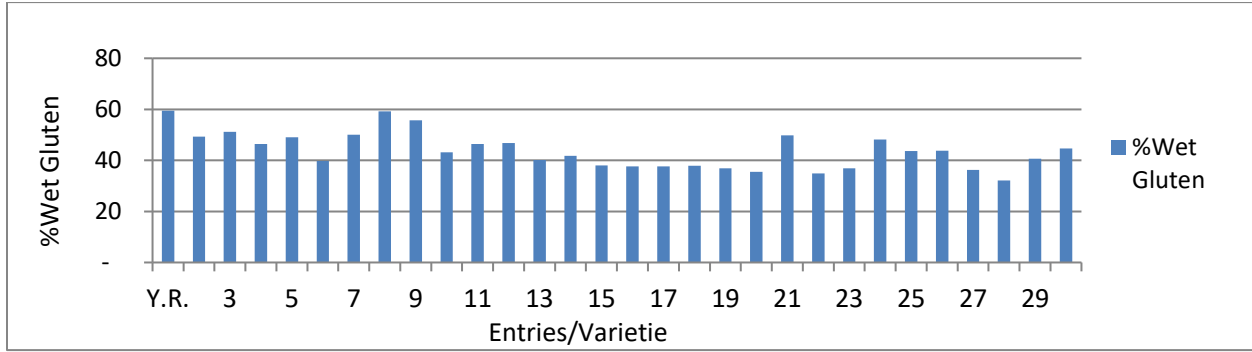


Figure 6, %Wet gluten on the flour samples of the 3<sup>rd</sup> EBW entries/varieties in 2008 cropping season

Table 4. Agronomic characters of ten selected bread wheat entries/varieties of 2009 trial.

Entry/ Variety	Area (M <sup>2</sup> )	Plant Height (cm)	Days at 100% Heading	No. for Days for Maturit y	Spike length (cm)	No. of Spikes Per M <sup>2</sup>	No. of Seeds per Spike	TGW	Specific Density Kg/hl	Test Harvest Kg/ M <sup>2</sup>	Potential Yield M.T. /Ha.
29-A	100	90	107	144.6	10.2	656.8	59	43.1	83.68	1.02	10.2
19-B	100	82.2	101	145.2	10.7	555.6	62	44.4	82.04	0.98	9.8
25-C	100	93.7	99.8	138.6	11.3	570	56	45.5	82.44	0.93	9.3
27-D	100	87.4	100.2	140	10.8	557.2	70	47.7	82.64	0.94	9.4
11-E	100	94.2	105	145.2	10.4	642.4	56	42.9	80.38	1.02	10.2
8-F	100	91.8	102.4	144.6	9.5	618.8	57	43.6	83.24	0.93	9.3
3-G	100	90.5	100.4	145.4	9.2	617.2	62	45.1	81.16	0.97	9.7
24-H	100	87.7	100.4	144.8	10.7	633.2	64	36.4	83.16	0.97	9.7
4-I	100	89.8	106.2	145.6	10.1	622	63	41.4	81.14	0.98	9.8
Y.R...*	100	67.6	99.6	137.4	9.6	591.2	62	45.2	82.68	0.94	9.4

\* Y. R.: Yecora Rojo



Figure 7, Different wheat plants entries/varieties plots of the 3<sup>rd</sup> EBW on April 14, 2009.

showed TGW ranged 36.4 – 47.7 grams which was very high. We observed high TGW value on the following entries/varieties in descending order # 27, 25, Y.R., 3, 19, 8 and 29 with TGW value 47.7, 45.5, 45.2, 45.1, 44.4, 43.6, 43.1 grams respectively. Increased TGW indicates good grains quality.

**B2- Productivity** [3]: Data on the test harvest of each entry/variety kg/M<sup>2</sup> shown in **Table 4** was calculated as metric ton per hectare and is represented in **Table 5** for comparison with previous season. Entry/variety # 11 produced the highest yield as it reached 10.024 M.T. /Ha followed by Entry # 29 with 10.018 M.T. /Ha then entry # 19 with 9.84 M.T. /Ha then entry # 4 with 9.76 M.T. /Ha.

It is clear from **Table 5** that the highest producing entry in 2008 & 2009 trials was entry # 29 as it reached an average Of 10.264 M.T/ Ha followed by entry # 19 with an average 10.215 then entry # 11 with an average 9.847 then entry # 27 with an average 9.545. In comparison Yecora Rojo variety rank was the tenth with an average 8.97 M.T. /Ha. In 2009 results, we observed that entry # 29 produced high number of spikes /M<sup>2</sup> as it reached 657 spikes/M<sup>2</sup>, also its test weight was the highest and it reached weight reached 83.68 kg/hl and this explains the reasons for high productivity of this entry/variety among the other entries.

Statistical analysis for the productivity in 2009 season showed no significant difference between the entries. However, we found the difference in the productivity between the highest producing entry # 11 and Yecora Rojo variety is 8.94% followed by entry # 29 with the difference 8.29% from Yecora Rojo. Also the difference between Yecora Rojo and the lowest producing entry # 8 equals 0.85%.

The following illustrate the detailed statistical analysis for the

entries productivity in 2009 trial estimated as kg/M<sup>2</sup>  
Randomized Complete Block AOV Table for Yield Kg/M<sup>2</sup>

Source	DF	SS	MS	F	P
Blocks	4	0.03353	0.00838		
Variety	9	0.05116	0.00568	0.81	0.6087
Error	36	0.25211	0.00700		
Total	49				

Note: SS are marginal (type III) sums of squares

Grand Mean 0.9686 CV 8.64

Tukey's 1 Degree of Freedom Test for Nonadditivity

Source	DF	SS	MS	F	P
Nonadditivity	1	0.00475	0.00475	0.67	0.4179
Remainder	35	0.24736	0.00707		

Relative Efficiency, RCB 1.02

Means of Yield Kg/M<sup>2</sup> for each Variety

Variety	Mean
29-A	1.0180
19-B	0.9840
25-C	0.9340
27-D	0.9360
11-E	1.0240
8-F	0.9320
3-G	0.9700
24-H	0.9720
4-I	0.9760
Y.R.	0.9400
Observations per Mean	5
Standard Error of a Mean	0.0374
Std Error (Diff of 2 Means)	0.0529

**Table 5: Summary of the Productivity expressed as M.T. /Ha in the 2008 & 2009 seasons.**

Variety	Actual Productivity 2008	Test Harvest 2008	Test Harvest 2009	Average of Test Harvest
29-A	9.600	10.510	10.018	10.264
19-B	9.130	10.590	9.840	10.215
25-C	8.730	9.460	9.340	9.400
27-D	8.470	9.730	9.360	9.545
11-E	8.650	9.670	10.024	9.847
8-F	7.470	9.150	9.320	9.235
3-G	6.810	8.410	9.700	9.055
24-H	8.070	9.110	9.720	9.415
4-I	7.400	8.740	9.760	9.250
Y.R*.-J	7.790	8.540	9.400	8.970

\* Y. R.: Yecora Rojo

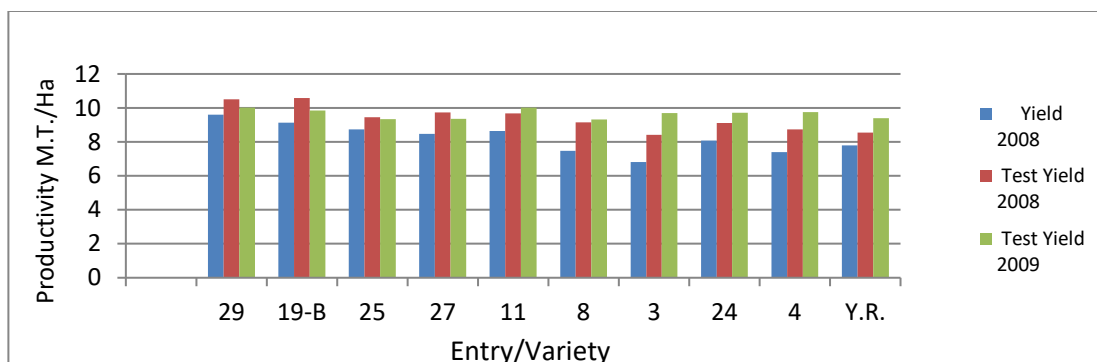


Figure 8, Comparison of actual yield of 2008 season with the test yield of 2008 and 2009 of the selected ten entries/varieties.

C2- Grains quality in 2009 [6], [7]:

Analysis results on the grains samples of the 2009 field trial are presented **Table 6**; the results had shown the following:

1- % Crude Protein: The grains analysis results shown the % crude protein ranged from 12.84 - 15.02% which was relatively less than the results in 2008 which ranged 14.66 – 17.84%. Increased productivity in 2009 season compared to 2008 season caused a decrease on the grains crude protein content. The grains samples of the entries/varieties # 8, 25, 19, 24, 11 contained higher percentage of crude protein in descending order as they reached 14.22, 14.04, 14.02, 14.02, 13.28% respectively; Yecora Rojo was the highest as it reached 15.02%; increased % crude protein is an indication of high quality of the grains.

2- % Moisture Content: The % moisture content on the grains samples ranged from 9.0 – 9.9 which were relatively high in comparison of the analysis results in 2008 which ranged 6.32 – 8.36%, and these results were acceptable for grains storage.

3- % Starch: The grains samples analysis results shown the

% starch ranged from 68.40 to 70.60% which was relatively high on all of the varieties in comparison of the results in 2008 which ranged 60.5 – 64.60%; Yecora Rojo in 2009 was with %starch content 70.10. High %starch in the grains was due to the weather temperatures in 2009 season was relatively with less minimum and maximum day temperatures in comparison with 2008; in addition of longer growing period in 2009 compared to 2008 which was late planted. We observed during the period April 11 to May 11, 2009 relatively low temperatures which correspond to the stages of anthesis until the hard dough stage on most of the days and in particular the grains filling period, see **Figure 10**. This affected the crop productivity and the grains components of the ten entries/varieties of 2009. Research reports on spring wheat shown that higher temperature in the range 25 - 35°C after anthesis and during the grain-filling period was an important yield limiting factor for wheat crop, and reductions in grain weight was caused by the reduced deposition of starch [12], [13].

Table 6. Summary analysis results on the grains samples of the 2009 wheat trial.

Varieties	%Crude Protein	Moisture Content	%Wet Gluten	%Starch	Zeleny Number
29 - A	12.90	9.60	28.92	70.60	46.06
19 - B	14.02	9.90	34.68	70.60	55.32
25 - C	14.04	9.40	33.40	69.50	54.56
27 - D	13.04	9.30	31.30	73.20	47.52
11 - E	13.28	9.50	30.16	70.00	49.88
8 - F	14.22	9.70	31.58	69.20	53.84
3 - G	12.84	9.70	29.62	68.40	46.74
24 - H	14.02	9.80	32.16	69.70	53.46
4 - I	13.10	9.10	29.58	70.00	48.74
Y.R*.	15.02	9.00	37.30	70.10	60.58
Mean	13.65	9.5	31.87	70.13	51.67

\* Y. R.: Yecora Rojo

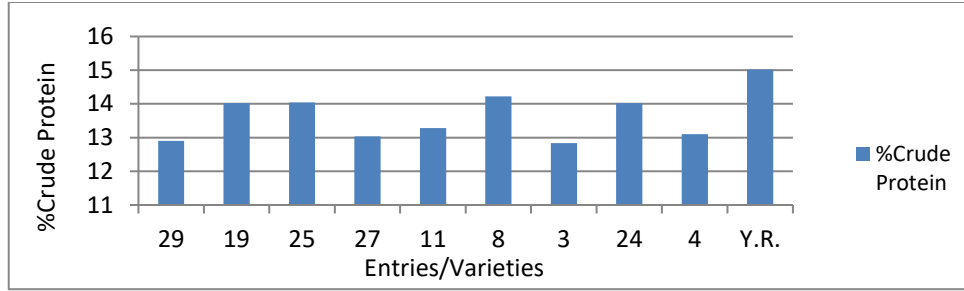


Figure 9. % Crude protein on the grains of ten entries/varieties of the 3<sup>rd</sup> EBW in the 2009 cropping season

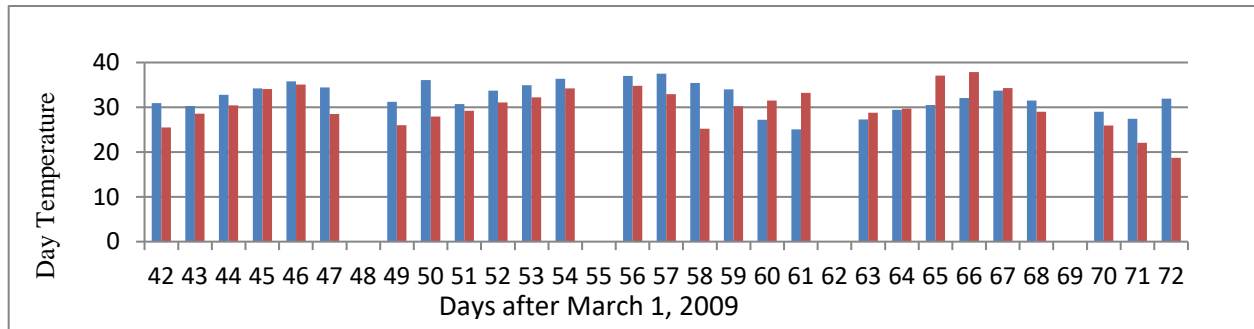


Figure 10. Comparison of maximum day temperature in 2008 season (blue) vs 2009 season (red) during the period April 11 until May 11, 2009.

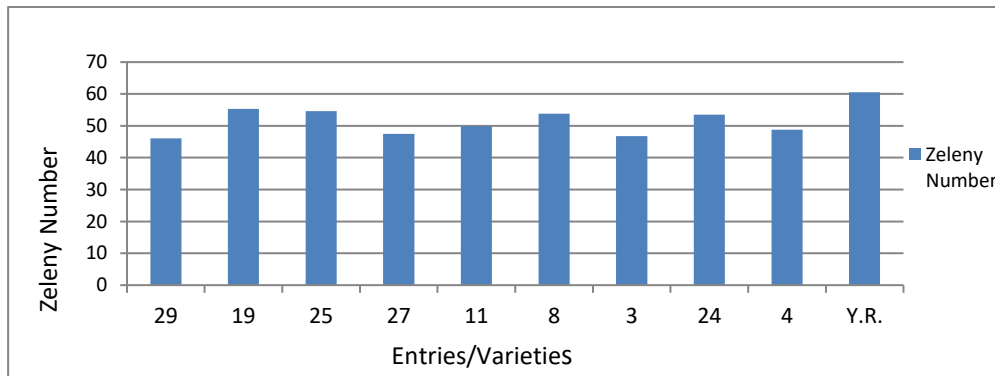


Figure 11. % Zeleny number on the grains of ten entries/varieties of the 3<sup>rd</sup> EBW in the 2009 cropping season

**4- % Wet Gluten:** We observed that the grains samples of the entries/varieties # 19, 25, 24, 8, 27 contained high percentage of wet gluten in descending order as they reached 34.68, 33.40, 32.16, 31.58, 31.30% respectively; Yecora Rojo was the highest as it reached 37.30%. Increased % wet gluten is an indication of high quality of the grains.

**5- Zeleny Number [7]:** This measures the quality and quantity of gluten and in particular the glutenin which controls the dough strength. Increased Zeleny number is an indication of more dough strength which is desired in good quality of wheat flour. We observed that the grains of the entries/varieties # 19, 25, 8, 24, 11 were with high Zeleny number in descending order 55.32, 54.56, 53.84, 43.46, 49.88; Yecora Rojo was the highest with 60.58, see **Figure 11**

**D2- Flour quality in 2009 [9], [10], [11]:**

Results on the analysis of the whole wheat flour samples are presented in **Table 7** had shown the following:

**1- % Crude Protein:** We observed that the wheat flour samples of the entries/varieties # 8, 25, 19, 24, 11 contained high percentage of crude protein in descending order as it reached 14.13, 13.83, 13.67, 13.67, 13.50%; Yecora Rojo was the highest as it reached 15.03%. Increased % crude protein is an indication of high flour quality.

**2- % Wet Gluten:** We observed that the flour samples of the entries/varieties # 25, 24, 8, 19 contained medium percentage of wet gluten in descending order as it reached 31.23, 30.27, 29.07, 28.53%. Yecora Rojo reached 33.33%. Increased

percentage of wet gluten is an indication of high flour quality.

**3- % Moisture Content:** The percentage moisture content in the flour samples range was 9.0 – 9.9%, which is relatively very high in comparison of the results in 2008 cropping season; the moisture content of Yecora Rojo flour sample was high and it reached 9.0%. Increased relatively high %moisture content was due to testing fresh harvested samples before the onset of high summer temperature.

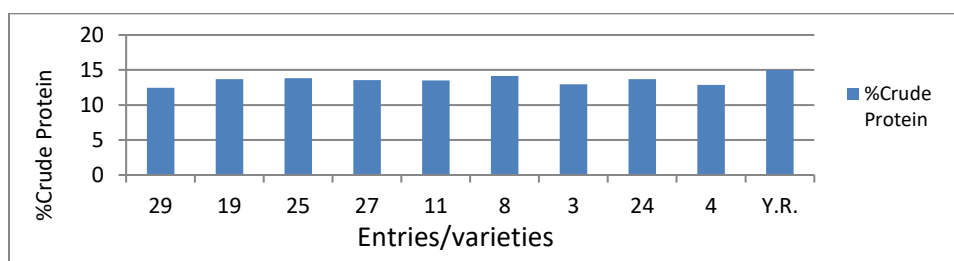
**4- % Ash:** We observed that the flour samples of the entries # 19, 29, 25, 27 contained low level of ash in ascending order as they contained 1.03, 1.08, 1.11, 1.11% respectively in

comparison with Yecora Rojo which reached 1.17%. Low % Ash is desired in the wheat flour as the flour color appears whiter, while high % Ash in the flour appears less white color.

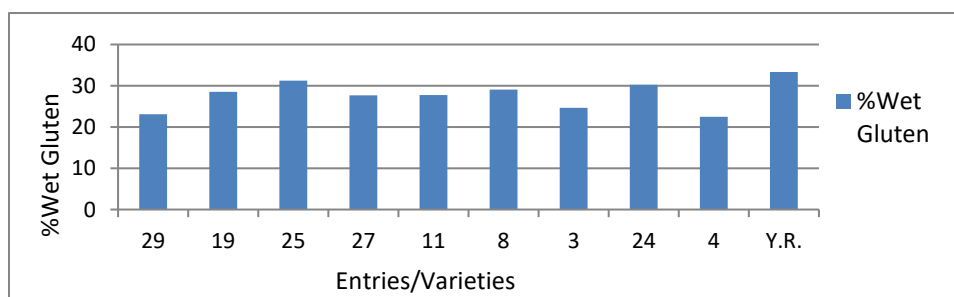
**5- % Water Absorption:** Water absorption in the different samples of the entries/varieties ranged from 61.30 – 62.20%, and it was acceptable. Normal value for water absorption in bread wheat range is 60-66%, and high value is desired in the flour of bread wheat. Increased relative % water absorption of the flour is desired by the bakeries as it produces more bread quantity.

**Table 7. Summary analysis results of the flour samples of the 2009 wheat trial.**

Varieties	%Crude Protein	Moisture Content	%Ash	%Water Absorption	%Wet Gluten
29 - A	12.47	9.6	1.08	61.3	23.13
19 - B	13.67	9.9	1.03	61.97	28.53
25 - C	13.83	9.4	1.11	62	31.23
27 - D	13.53	9.3	1.11	61.8	27.67
11 - E	13.5	9.5	1.13	62.07	27.77
8 - F	14.13	9.7	1.08	62.2	29.07
3 - G	12.97	9.7	1.12	61.97	24.67
24 - H	13.67	9.8	1.11	62	30.27
4 - I	12.87	9.1	1.11	62.1	22.5
Y.R	15.03	9	1.17	61.57	33.33
Mean	13.40	9.5	1.10	61.90	27.82

















**Figure 11. % Crude protein on the flour samples of ten entries/varieties of the 3<sup>rd</sup> EBW in the 2009 cropping season.**



**Figure 12. % Wet Gluten on the flour samples of ten entries/varieties of the 3<sup>rd</sup> EBW in the 2009 cropping season.**



Summary for the evaluation on the third elite bread wheat entries/varieties are presented in the following **Table 8** [4], [15]:

Entry/ Varieties	Pedigree as per CIMMYT	Entry/ Variety Foliage	Entry/ Variety Seeds	Character
24	WAXWIN G*2/KIRIT ATI			Height 87.7 cm, Maturity 145 days, White grains color. Protein 14.02%, Zeleny number 53.46, % Wet Gluten 32.16, % Ash 1.11, % Water absorption 62.0, High yield and High Quality
19	PFAU/WE AVER*2// KIRITATI			Height 82.2 cm, Maturity 145 days, Light red grains color. Protein 14.02%, Zeleny number 55.32, % Wet Gluten 34.68, % Ash 1.03, % Water absorption 61.97, High yield and High Quality.
11	SERI.1B*2 /3/KAUZ* 2/BOW//K AUZ/4/PB W343*2/K UKUNA			Height 94.2 cm, Maturity 145 days, Light red grains color. Protein 13.28%, Zeleny number 49.88, % Wet Gluten 30.16, % Ash 1.13, % Water absorption 62.07, High yield and High Quality.
25	WAXWIN G*2/4/SNI/ TRAP#1/3/ KAUZ*2/T RAP//KAU Z			Height 93.7 cm, Maturity 139 days, White grains color, Protein 14.04%, Zeleny number 54.56, % Wet Gluten 33.40, % Ash 1.11, % Water absorption 62.0, High yield and High Quality.
27	WBLL1*2/ KIRITATI			Height 87.4 cm, Maturity 140 days, White grains color, Protein 13.04%, Zeleny number 47.52, % Wet Gluten 31.30, % Ash 1.11, % Water absorption 61.8, High Yield.
29	WAXWIN G*2/KIRIT ATI			Height 90 cm, Maturity 145 days, Light red grains color, Protein 12.90%, Zeleny number 46.06, % Wet Gluten 28.92, % Ash 1.08, % Water absorption 61.3, High yield.
8	PBW343*2 /KUKUNA //KIRITAT I			Height 91.8 cm, Maturity 145 days, Light red grains color, Protein 14.22%, Zeleny number 53.84, % Wet Gluten 31.58, % Ash 1.08, % Water absorption 62.2, High Quality.

3	KIRITATI/ /2*PBW65/ 2*SERI.1B			Height 90.5 cm, Maturity 145 days, Maturity 145 days, Red grains color, Protein 12.84%, Zeleny number 46.74, %Wet Gluten 29.62, %Ash 1.12, % Water absorption 61.97, High yield.
Y.R.	Cross of (Ciano X Sonora 64- Klien Rendidor) X 8156			Height 67.6 cm, Maturity 137 days, Red grains color, Protein 15.02%, Zeleny number 60.58, % Wet Gluten 37.30, %Ash 1.17, % Water absorption 61.57, High yield.

**Additional observations on the 3<sup>rd</sup> elite bread wheat trials:** As per the final results, we planned in 2010 season to propagate selected four entries/varieties shown high productivity and high quality in 2009 season for the purpose of future bread wheat varietal development. The selections were the entries # 19, 24, 25 and 29. We succeeded to produce seeds quantities shown in the following **Table 9**:

Entry/Variety #	Description	Seeds Quantity (Kg)
19 - B	High productivity and high quality	1220
24 - H	High productivity and high quality	1060
25 - C	High productivity and high quality	1120
29 - A	High productivity	1220

Furthermore, we milled 50 kg of each entry/variety of # 19 and 24 in a local mill to test the toast bread of each using household sieve for flour extraction. The results of baking shown the outer color of the toast loaf was light brown and the inner bread color was golden yellow; the bread taste was excellent and melts in the mouth, see **Figure 13**.



**Figure 13. Wheat bread toast loaf of two entries/varieties number 19 and 24.**

#### IV. CONCLUSION

1- Two years field trials on 29 bread wheat entries/varieties of the 3rdEBW from the CIMMYT nurseries shown promising results towards the development of new varieties suitable for the end user in the middle east countries.

2- Results in 2008 field trial shown the productivity [3] of the entry/variety # 29 was the highest with 9.6 M.T. /Ha followed by the entry # 25 with 8.73 M.T. /Ha then entry # 11 with 8.65 M.T. /Ha then entry # 27 with 8.47 M.T. /Ha. Yecora Rojo productivity ranked 8th with 8.19 M.T. /Ha, and it was less than the productivity of entry # 29 by 17.22%.

Entry # 29 yield was the highest due to high number of spikes/M<sup>2</sup> which reached 672 combined with high test weight which reached 84.20 kg/hl. The potential yield of entry/variety # 19 reached 10.59 M.T./Ha followed by entry # 23 with 10.39 M.T./Ha then entry # 22 with 10.34 M.T./Ha; the potential yield of Yecora Rojo reached 9.52 M.T./Ha. Comparison of agronomic characters in 2008 shown Yecora Rojo was the shortest variety with height 64.6 cm followed in ascending order entries/varieties # 19, 18, 5, 6 with height 76.5, 81.6, 82.9, 82.9 cm respectively; it is desired to get a dwarf wheat variety to overcome lodging

problem and secure good quality. Entries/varieties # 20, 21, 22, 12, 6, 9 were with early maturity as they ranged 119 – 121 days similar to Yecora Rojo with 121 days.; it is a desired character to get an early maturing variety to save energy and water.

3- Results in 2009 field trial shown the productivity [3] of the entries/varieties # 29, 11 were the highest, and both were with 10.02 M.T./Ha followed by entry # 19 with 9.84 M.T./Ha then entry # 4 with 9.76 M.T./Ha; Yecora Rojo productivity ranked 7th with 9.40 M.T./Ha. The yield of entry/variety # 29 was the highest due to high number of spikes/M<sup>2</sup> which reached 657 combined with high test weight which reached 83.68 kg/hl. Comparison of agronomic characters in 2009 shown Yecora Rojo was the shortest variety with height 67.6 cm followed in ascending order entries/varieties # 19, 27, 24 and 29 with height 82.2, 87.4, 87.7, 87.7 cm respectively. entries/varieties # 25, 27, 8, 24, 29 and 19 were with early maturity as they reached maturity stage after 139, 140, 145, 145, 145 days which was slightly longer than Yecora Rojo with 137 days.

4- The analysis results of the grains samples [6], [7] in 2008 season shown that the entries/varieties # 8, Y.R, 9, 3, 4 and 2 were with high protein content and it ranged 16.17 – 17.48%; also the %wet gluten of the entries/varieties # 6, 9, 13, 3, 2, 7 were higher than on other entries/varieties and it ranged 34 – 38.23%. Zeleny number, which measures the quality and quantity of gluten, was higher on the entries # 8, 3, 24, 2, 5 than on other entries, and it ranged 67.33 – 68.23%. Increased values of %crude protein, %wet gluten and Zeleny number are indicators of good grains quality as they indicate an increase in the dough strength. In comparison Yecora Rojo was with medium wet gluten content of 32.07% and with high Zeleny number of 66.63. The %Moisture content of the grains samples in 2008 ranged 6.42 – 8.36% which was acceptable for the seeds storage, and the %Starch of the grains samples ranged 60.60 – 64.60% which was relatively low, and it was acceptable.

5- The analysis results of the grains samples in 2009 season [6], [7] shown that the entries/varieties # 8, 25, 19, 24, 11 were with higher protein content than on other entries and it ranged 13.28 – 14.22%; also the %wet gluten of the entries/varieties # 19, 25, 24, 8, 27 was higher than on other entries/varieties and it ranged 31.58 – 34.68%. Zeleny number was higher on the entries 19, 25, 8, 24, 11 than on other entries, and it ranged 49.88 – 55.32%. In comparison Yecora Rojo was with higher %crude protein, %wet gluten and Zeleny number of the values 15.02%, 37.30%, 60.58 respectively. The %Moisture content on the grains samples in 2009 ranged 9.0 – 9.9%, and it was acceptable for seeds storage, and the %Starch of the grains samples ranged 68.40 – 70.60% which was high, and it was acceptable.

6- The analysis results of the flours samples in 2008 season [9], [10], ([11] shown the entries/varieties # 8, 3, 9, 5 were with high %crude protein content and it ranged 17.48 –

17.79%; also the %wet gluten of the entries/varieties # 8, 9, 3, 7, 21 were higher than on other entries/varieties and it ranged 49.77 – 59.21%. Increased values of %crude protein, %wet gluten are indicators of good flour quality as they indicate an increase in the dough strength. In comparison Yecora Rojo was with higher % crude protein, and higher %wet gluten of the values 17.86%, 59.43% respectively. The analysis results of the flours samples in 2009 season shown the entries/varieties # 8, 25, 19, 24, 11 were with higher %crude protein content and it ranged 13.50 – 14.13%; also the %wet gluten of the entries/varieties # 25, 24, 8, 19 were higher than on other entries/varieties and it ranged 28.56 – 31.23%. In comparison Yecora Rojo was with higher % crude protein, and higher %wet gluten of the values 15.03%, 33.33% respectively.

7- Comparative analysis results of 2008 and 2009 on the grains and flour samples shown changes on the grains components due to increased productivity in 2009 cropping season in comparison of 2008 cropping season. The day and night temperature during the period April 11 and May 11 in 2008 was higher than in 2009; also there was delay in the date of sowing in 2008. These factors affected the crop productivity and the grains components of the ten entries/varieties of 2009. Research reports shown that higher temperature in the range 25 – 35°C after anthesis and during the grain-filling period was an important yield limiting factor for wheat crop, and reductions in grain weight was caused by the reduced deposition of starch [12], [13].

For the grains samples, the mean %crude protein of the ten entries in 2009 was less than 2008 by 2.68%, and the mean Zeleny number in 2009 was less than 2008 by 13.31 due to increased yield in 2009. The mean %starch in 2009 season was 70.18%, and this was higher than in 2008 season by around 8.1% due to increased productivity in 2009; also the mean %moisture content of the grains in 2009 season was higher than in 2008 by around 2.5% due to mild weather in 2009. No significant change on the grains wet gluten.

For the flour samples, the mean %crude protein in the samples of 2009 was less than in 2008 by 2.3% and the mean %wet gluten in 2009 was less than 2008 by 18.7% due to increased yield in 2009. The mean %moisture content in 2009 was higher than in 2008 by 3.3% due to mild weather in 2009 season. Little changes were observed in the %ash content and %water absorption in the flour samples

8- The overall results in 2008 shown three entries/varieties of high quality and high productivity # 11, 19, 25 and four entries/varieties of high quality # 3, 4, 8, 24; and two entries/varieties of high productivity # 27, 29. In conclusion of 2008 and 2009 cropping seasons results: entries/varieties with high yield and high productivity were # 11, 19, 24 and 25; entries with high yield were # 27, 29 and entries with high quality were # 4 and 8,

9- As per the Saudi government policy in 2008, they started reducing wheat purchases from local farming by an annual



rate of 12.5% to save underground water, and this significantly affected the cultivated area of wheat crop [16], [17]. So, no further research activities were directed to the wheat varieties. These results are of valuable importance in other wheat growing countries in the middle east who are looking for excellent bread wheat varieties. The author kept small samples of the entries as a reference.

#### ACKNOWLEDGMENT

The authors wish to thank TADCO CEO, Eng'r Saad Al Swat, and Dr. Abdul Monim Ali CBDO for their continuous support during this study. The authors wish to thank the lab unit head Mr. Conrad Angeles and his staff. Special thanks to the Administrative Assistant Mr. Isaac Obra for drawing trials lay out and for printing the Lab reports for the grains and flours analysis at TADCO.

#### REFERENCE

- [1] Curtis B.C. Wheat in the world in the book entitled: Bread Wheat, FAO Plant Production and Protection Series, No 30. FAO 2002. <http://www.fao.org/3/Y4011E/y4011e04.htm#bm04>
- [2] Al Tamimi, S.A. (1988). Wheat production under Centre pivot irrigation system in the kingdom of Saudi Arabia. Research Dept., MOA, Riyadh, Saudi Arabia.
- [3] Naser I. et al (2020). Evaluation of four Australian Bread Wheat Varieties Grown Under Centre Pivot Irrigation System. Volume 7 Issue 6, 2020, pp 1-17 [www.internationaljournalssrg.org/IJAES/index.html](http://www.internationaljournalssrg.org/IJAES/index.html)
- [4] CIMMYT 2007. 3RD ELITE BREAD WHEAT YT, Global Wheat Program & Wheat Improvement, Nursery name 3EBWYT. <https://www.cimmyt.com>
- [5] Foss Co (2016). Grain Analyzer Infratec 1241 <https://www.fossanalytics.com/products/infratec-1241>
- [6] Description of wheat quality factors, California Wheat Commission <http://cawheat.org/milling/description-of-wheat-quality-factors/>
- [7] Kernel Analysis <https://www.ndsu.edu/faculty/simsek/wheat/kernel-analysis.html>
- [8] Pena, R.J. (2002). Wheat for bread and other foods in the book entitled: Bread Wheat Improvement and Production, FAO Plant Production and Protection Series, No 30. FAO 2002. <http://www.fao.org/3/y4011e0w.htm#bm32>
- [9] Wheat and Flour Testing Methods: A Guide to Understanding Wheat and Flour Quality: Version 2. <https://webdoc.agsci.colostate.edu/wheat/linksfiles/WheatFlour.pdf>
- [10] Flour Analysis <https://www.ndsu.edu/faculty/simsek/wheat/flour.html>
- [11] Sorenson, B.K. (2013). What is wheat quality and why it matters. NDSU Extension service, North Dakota, USA. <https://wenku.baidu.com/view/9f258e6bcaedd3383c4d3a9.html>
- [12] Wardlaw, I.F., Dawson, I.A., Munibi, P., and Fewster, R. (1989b). The tolerance of wheat to high temperatures during reproductive growth. I. Survey procedures and general response patterns. Australian Journal of Agricultural Research 40, 1-13.
- [13] Jenner, C.F. (1994). Starch synthesis in the kernel of wheat under high temperature condition, *Aust.J.Plant Physiol.* Vol. 21, pp791 – 806. <https://www.researchgate.net/publication/262995039>
- [14] Bhullar, S.S., and Jenner, C.F. (1985). Differential responses to high temperatures of starch and nitrogen accumulation in the grain of four cultivars of wheat. Australian Journal of Plant Physiology 12, 363-375. <https://www.researchgate.net/publication/262994732/>
- [15] Calvin O. Qualset, H.E. Vogt, NE Boriaug (1985). Registration of 'Yecora Rojo' Wheat, Crop Science. Vol. 25 (6), pp 1129 – 1130. [https://www.researchgate.net/publication/250113725\\_Registration\\_of\\_'Yecora\\_Rojo'\\_Wheat](https://www.researchgate.net/publication/250113725_Registration_of_'Yecora_Rojo'_Wheat)
- [16] Anonymous. Saudi Arabia to stop wheat production by 2016 <https://english.alarabiya.net/en/business/economy/2014/12/11/KSA-to-stop-wheat-production-by-2016>
- [17] Arab News. Kingdom to halt wheat production by 2016, Arab news, April 2013. <https://www.arabnews.com/news/448070>