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Comparison of some Italian and Iraqi bread wheat varieties in respond to Eco-zinc application

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Abstract

This study was carried out at the fields of Agricultural College, University of Duhok during the growing season 2015/16 to investigate the performance of four wheat varieties; Zanzibar, Nogal (new Italian varieties), Adana-99, and Al-Iraq (local varieties) in respond to eco-zinc fertilizer application (control, seed soaking in eco-zinc, foliar application of eco-zinc, and conventional NPK fertilizer) under rainfed conditions of Duhok province. The experiment was arranged in RCBD design with three replications. Both local varieties were superior in field emergence and plant height as compared to Italian varieties, whereas the Italian surpassed local varieties in most of spike characteristics and harvest index but inferior in 1000 grains weight and the later was the most effective trait in which affected grain qualities for the two new varieties. Each of Nogal (4577 kg.ha^{-1}) and Adana-99 (4552 kg.ha^{-1}) varieties significantly produced higher grain yield and biomass yield. Most of growth characteristics were not affected by the application of eco-zinc fertilizer while the spike density enhanced significantly (*F Prob.*= 0.008). The final grain yield was significant and higher when seed soaked in eco-zinc solution (4609 kg.ha^{-1}).The two Italian were late in maturity for about 10 days from the local varieties and this was the reason for extending the grain filling period to correspond the stress of high temperatures and low moisture in May, and accordingly they are not recommended to be sown under similar conditions unless an alternative source of supplementary irrigation is available.

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Introduction

Wheat (*Triticum aestivum* L.) is one of the oldest domesticated food crops. Already 8000 years ago it has considered the basic staple food of the major world civilizations (Curtis *et al.,* 2002). Carbonized wheat grains that back to about 6750 were found at Jarmo in eastern Iraq (Leonard and Martin, 1963). Today, wheat is grown on more land area than any other commercial crop (Carena, 2009). Wheat is used mainly for human consumption, animal feeding, industry and biofuel (Gooding and Davies, 1997; FAO, 2009). FAO (2012) reported that the global wheat expected to pass 722 million tons (mt) in 2018 compared to 690 mt in 2012.

The path to local and global food security faces numerous challenges, during the two generations; the global population grew by 90%. Although food production expanded by 115% during this period, inveterate hunger still sustains more than 800 million people and about 1200 million people live on 1 $ or less per day; wheat, along with maize and rice underpin the world food supply, providing 44% of total edible dry food and 40% of energy consumed in developing countries (Buck *et al.*, 2007). According to OECD/FAO (2011, 2012) and FAO (2010), 1.05% annual growth of world population is expected between 2011 and 2020, compared with 1.2% in the previous decade. Moreover, the reports expect that in 2020 wheat prices are projected above historical average and world wheat production is projected to increase by 11%, but with slower annual growth relative to the previous periods; the reports concluded that by 2021 the developing countries will provide the main source of global production growth(+1.9%) compared to (1.2%) for the developed countries. Therefore, an increase in wheat production is necessary to supply enough food to the growing world population and demand the livestock requirements.

Global wheat production has increased significantly due to breeding programs and improved production technologies since the 1960s. The world average wheat yield has increased more than double from 1.1t.ha^{-1} in 1961 to 2.83t.ha^{-1} in 2007; the highest yields were in European countries, while Asian countries tend to obtain yields slightly below the world average (FAO, 2009).

In Iraq and Kurdistan region, wheat is usually grown under rain-fed conditions which characterized with irregular precipitation and distribution along with low yielding varieties, leading to stress with serious negative consequences on wheat production and productivity. The yield per hectare at all Iraqi Kurdistan areas during the 2009-2013 was 656, 988, 772, 796, and 1064 kg, respectively (MAWR, 2015).

The net yield in wheat crop is influenced by numerous factors, cultivars, environments and cultural practices including fertilizers which have a great effect on wheat productivity. Therefore, yield improvement through seeking for new varieties and cultural practices such as fertilizers application (e.g. eco-zinc) can grow up the wheat production in the area. Zinc is one of the most functional micronutrients in plants and animals including human beings; it plays an important physiological role in their growth and development (Cakmak, 2008). Zn deficiency is common in both plants and animals causing different serious health complications such as growth inhibition, diseases susceptibility, mental complexes due to restrictions in brain development, etc. (Fraga, 2005); it is estimated that more than one third of the population is affected by Zn deficiency, particularly children and pregnant women; moreover, low Zn dietary intake has been discussed as a major reason for above problems (White *et al.*, 2009).

Therefore, enrichment of cereal crops with Zn is an important world challenge. The availability of Zn in soil can be affect by many factors especially soil pH and soil nutrients (Bukvic *et al.,* 2003); therefore, foliar application can overcome this obstacles. (Cakmak *et al.* 2010) reported that Zn in wheat grain is different among wheat cultivars and is significant for growth and grain nutritional quality characteristics. Monasterio *et al.* (2002) stated that Zn is important for growth vigorous in wheat and has a rule for activating of some enzymes such as dehydrogenase and proteinase.

On the other hand, Salimpour *et al.* (2010) explained that Zn is adversely affect in relation to some other nutrients such as phosphorus; the plant uptake is decreased with the increasing of P doses in the soil and vise versus; this antagonism may cause serious yield reduction in wheat.

Similarly, Keram *et al.* (2012) illustrated that wheat yield and harvest index were increased by Zn fertilizer application and the nutrient uptake enhanced excluding phosphorus; they recommended 20 kg. ha^{-1} Zn with normal NPK fertilizer. El-Habbasha *et al.* (2015) reported that wheat varieties responded differently to the foliar application of Zn. Also, Arshad *et al.* (2016) and Rashid, *et al.* (2016) demonstrated that Zn application significantly increased wheat yield components such as spike characteristics and weight of 1000 grains which consequently increased final grain yield.

On the other hands, wheat varieties responded differently to the rained environments and fertilizer application. Stapper and Harris (1989) demonstrated that the environmental conditions and stress on wheat production is high in Mediterranean areas, they implemented different studies for various wheat varieties in many different areas of Syria with rainfall ranged between 280 and 480 mm; they observed significant variations in final grain yield varied from 2.17 to 4.71 t. ha^{-1}consequently, and they concluded that an early maturing varieties are more suitable for the driest regions.

Objectives of the study

Wheat yield improvement through seeking for new varieties and cultural practices such as fertilizers application (e.g. eco-zinc) can grow up the wheat production in the area. Furthermore, the organic fertilizers are friendly related to the environment and positively effect on the soil characteristics. Therefore, new Italian varieties were included in this study along with different eco-zinc applications in comparison to local varieties and traditional fertilizer application to investigate their performance under rainfall condition of Duhok province.

Materials and methods

Location and factors included

The research work was implemented during the growing season 2015/2016 at the fields and labs of Agricultural College, University of Duhok, Iraqi Kurdistan Region.

The study included two factors, four wheat varieties; Zanzibar (Ref. No. ITA B1484020150 E006), Nogal (Ref. No. ITA B1364820150E003); (new Italian Varieties), Adana-99, and Al-Iraq) and four fertilizer application (control, seed soaking in eco-zinc, foliar application of eco-zinc, and conventional NPK fertilizer) arranged in randomized complete block design (RCBD) with three replications.

Land preparation and factors description

Land was plowed a week before sowing and soil was smoothed by rotivator, the seeds were sowed in Dec., 22, 2015. The experimental units (2.4 m^2) included six rows with 2m long and 0.2 m a parts; 0.5 m between units and 1 m between replications. Seeds were sowed in a rate of 125 kg.ha^{-1}(Omer, 2015); the amount of seeds for each line was kept in a small bags to control the sowing process which was manually implemented taking in the accounts the seed weight and germination percentage for each variety (Omer *et al,* 2015).For seed soaking treatment, eco-zinc solution was prepared in a rate of 1:4 (100 ml eco-zinc + 400 lt water) and the seed for each variety was soaked for two minutes; air dried and sowed at the same day. Conventional NPK fertilizer was applied in a rate of 120 kg.$ha^{-1}$and the second part of urea was applied at tillering stage. Eco-zinc sprayed at the beginning of tillering stage at the early March in a rate of 5000 ml.ha^{-1}which corresponds to 1.2 ml.$unit^{-1}$.

Cultural practices and data collection

Broad and narrow weeds were controlled using Topic (40 ml.16 lt^{-1}) and Granistar (4g.16 lt^{-1}) herbicides when the wheat crop was at 4-5 leaf stage. Sunn pest was controlled using Super Serin insecticide (25 cm^3. 16lt^{-1}) at the beginning of grain development stage in May. All growth measurements (field emergence, SPAD leaf chlorophyll, flag leaf area, plant height) were calculated before harvesting. For yield and yield components measurements, one of the middle lines was harvested manually at 2/6/2016; five spikes were randomly selected for the further spike measurements.

Meteorological data for the experiment site were collected from the college of Agriculture meteorological station (Table 1); the data were analyzed using Gen Stat (2011) program and Least Significant Differences (L.S.D.) was used for the mean comparisons at the probability of 0.05.

Results and discussion

Growth Characteristics

All wheat growth traits were significantly affected by wheat varieties with the exception of leaf chlorophyll content (F Prob. = 0.109) (Table 2).

As for the eco-zinc treatments, only leaf chlorophyll content was significantly influenced (F Prob. = 0.04). The interaction of wheat varieties and eco-zinc treatments was not significant for all growth measurements. Both local varieties, Adana-99 and Al-Iraq were superior in field emergence (96.05 and 94.86 %) and plant height (86.37 and 87.77 cm) as compared to Italian varieties (Nogal and Zanzibar) (83.86 and 84.42 %) and (75.80 and 77.25 cm) respectively.

Table 1. Meteorological data of the research site* and weight of 1000 grains for the studied varieties.

Month	Ave. Max. Tem (C)	Ave. Min. Tem (C)	Rainfall (mm)	Wheat variety	Initial 1000 grains weight (g)
Oct. 2015	29.3	16.2	41.8	Zanzibar	48
Nov. 2015	18.7	6.9	58.4		
Dec. 2015	13.5	1.3	87	Nogal	38
Jan. 2016	10.6	1.4	90.5		
Feb. 2016	16.8	4.5	39	Adana-99	28.5
Mar. 2016	18.8	6.6	88		
Apr. 2016	25.7	11.0	40.6	Al-Iraq	30.3
May-16	31.6	14.9	2.8		
Jun-16	38.2	21.8	1.8		
Total			449.9		

* The data were collected from the meteorological station, college of Agriculture.

Variation in field emergence can be attributed to differences of the investigated wheat varieties, grain size and seed vigor, and climate conditions (Table 1). On the other hand, hand sowing of seeds can causes variation in sowing depths and distribution which has negative impact on field emergence and other characteristics.

Table 2. Analysis of variance and mean values for wheat varieties, eco-zinc fertilizer treatments and their interaction on some growth characteristics.

Source of variance	Probability of significance (*F Prob.*)			
	EMER* (%)	CHLO (SPAD)	FLAR (cm^2)	HGHT (cm)
Wheat varieties (V)	<.001	0.109	<.001	<.001
Eco-zinc treatments (E)	0.070	0.040	0.764	0.387
V * E	0.405	0.057	0.785	0.342
Residual D.F	15	15	15	15
Wheat varieties means				
Nogal	83.86	53.23	36.04	75.80
Zanzibar	84.42	53.62	30.22	77.25
Adana-99	96.05	52.21	36.81	86.37
Al-Iraq	94.86	51.54	45.38	87.77
L.S.D.	5.422	1.852	4.760	1.387
Eco-zinc treatment means				
Control (zero)	90.80	52.10	37.90	81.73
Seed soaking	87.22	52.58	35.94	81.18
Spraying	87.48	51.62	36.66	82.30
Conventional NPK	93.69	54.28	37.94	82.00
L.S.D.	5.422	1.852	4.760	1.387

* EMER, filed emergence; CHLO, SPAD leaf chlorophyll; FLAR, flag leaf area; HGHT, plant height .

Plant height is genetically controlled by genes (Richards, 1992; Rebetzke *et al.,* 2012), and it's also significantly influenced by the environment conditions. Also, it has been reported that semi dwarf varieties characterize with less CO_2 simulation compared to tall varieties in stress conditions due to less leaf water content (Nenova *et al.*, 2014). Similarly, Sojka *et al. (*1981) found that tall bread wheat and barley more resistance to drought conditions; semi-dwarf wheat is intermediate while durum wheat is most susceptible. Similar results regarding plant height for different wheat varieties were reported by Sharma *et al.*, 2010; Rebetzke *et al.*, 2012; Zareian *et al.*, (2012 & 2013) in different environments.

Table 3. Analysis of variance and mean values for wheat varieties, eco-zinc fertilizer treatments and their interaction on spike characteristics.

Source of variance	Probability of significance (*F Prob.)*			
	SLGT[1] (cm)	SPLSP (n)	SYSP (g)	SDENS SPL.10cm SP-1
Wheat varieties (V)	<.001	<.001	0.029	<.001
Eco-zinc treatments (E)	0.517	0.493	0.258	0.008
V * E	0.120	0.142	0.761	0.656
Residual D.F	30	30	30	30
Wheat varieties means				
Nogal	9.413	19.38	1.482	20.6
Zanzibar	8.425	17.28	1.295	20.5
Adana-99	9.320	16.10	1.212	17.3
Al-Iraq	9.497	16.32	1.152	17.2
l.s.d.	0.4386	0.807	0.2231	0.53
Eco-zinc treatment means				
Control (zero)	9.028	17.40	1.375	19.3
Seed soaking	9.193	17.55	1.332	19.1
Spraying	9.097	16.98	1.270	18.7
Conventional NPK	9.337	17.15	1.163	18.4
L.S.D.	0.4386	0.807	0.2231	0.53

[1]SLGT, spike length; SPLSP, number of spikelets per spike; SYSP, seed yield per spike; SDENS, spike density.

Al-Iraq significantly surpassed all others varieties in flag leaf area and recorded 45.38 cm^2;as for leaf chlorophyll content, both seed soaking in eco-zinc solution or foliar application of eco-zinc and control unit significantly were similar and inferior as compared to conventional application of NPK fertilizer; these results are highly agreed with those of Yasmeen *et al.* (2013) whom demonstrated that foliar growth treatments will not improve the leaf chlorophyll content and leaf area under non-irrigated conditions.

Also, Banziger and Cooper (2001) stated that the growth of wheat genotypes responded differently to the environment conditions.

Spike Characteristics

The effect of wheat varieties on the spike characteristics was significant, while the eco-zinc treatment was significant only for the spike density.

On the other hand their interaction between both studied factors was not significant on all spike traits (Table 3).

Nogal variety was superior in most of spike traits; also, this variety along with both Iraqis varieties (Al-Iraq and Adan-99) surpassed Zanzibar variety in spike length. Both Italian surpassed Iraqis varieties in spike density and number of spikelets per spike traits as they obtained about 21 spikelets per 10 cm spike length compared to 17 spikelets for the Iraqis.

Eco-zinc treatments affected significantly on the spike density only (*F Prob.*= 0.008) while the other treatment were not significant in relation to the spike characteristics.

Table 4. Analysis of variance and mean values for wheat varieties, eco-zinc fertilizer treatments and their interaction on yield and its components characteristics.

Source of variance	Probability of significance (*F Prob.)*					
	NSPK[1] (n.m^{-2})	NSSP (n.spike^{-1})	TGW (g)	GYLD (kg.ha^{-1})	BIOM (kg.ha^{-1})	HI
Wheat varieties (V)	0.216	<.001	0.005	0.003	0.001	0.038
Eco-zinc treatments (E)	0.420	0.127	0.376	0.046	0.955	0.485
V * E	0.955	0.127	0.980	0.688	0.518	0.849
Residual D.F	28	30	30	29	30	28
			Wheat varieties means			
Nogal	187.5	57.52	25.54	4577	12578	0.38
Zanzibar	184.0	51.08	25.42	4103	10808	0.39
Adana-99	205.3	39.28	30.77	4552	13160	0.35
Al-Iraq	187.0	41.03	28.15	4035	11729	0.34
L.S.D.	22.36	3.827	3.198	340.4	1138.5	0.037
			Eco-zinc treatment means			
Control (zero)	189.7	48.36	28.79	4171	12070	0.37
Seed soaking	192.4	49.30	27.45	4609	12196	0.38
Spraying	181.7	45.92	27.63	4238	11892	0.36
Conventional NPK	200.1	45.35	26.00	4249	12119	0.35
L.S.D.	22.36	3.827	3.198	340.4	1138.5	0.037

[1]NSPK, number of fertile spikes (tillers) per square meter; NSSP, number of seeds per spike; TGW, thousand grain weight; GYLD, grain yield; BIOM, above ground biomass; HI, harvest index.

Seed soaking in eco-zinc solution along with the control treatment significantly produced denser spikes. Spike density is the fraction of number of spikelets and spike length; therefore, there is a positive correlation (r= 64**) between number of spikelets and spike density (Table 5). Increasing and decreasing of the spikelets fertility and especially the basal spikelets and also most of the spike characteristics is mostly associated with the environment conditions (Saifuzzaman *et al.,* 2008). On the other hands, there is possibility of increasing the spikelet sterility in high plant densities (Mishra and Mohapatra, 1987), but in our study the sterility is mostly associated with high temperatures and low rainfall stress (Table 1).

Yield and yield components

The yield and yield components measurements are arranged in the table (4). Wheat varieties were significantly different in all yield and its components excluding number of spikes per unit area. Eco-zinc treatment significantly influenced on the final grain yield (*F Prob.*= 0.046), but all other yield components were not affected by the application of eco-zinc treatments. The interaction of varieties and eco-zinc treatment was not significant for all yield and its components.

Both Italian varieties were superior in number of seeds per spike and harvest index but inferior in 1000 grains weight as compared the Iraqis varieties and this was the most effective traits in which affected on the final grain yield for the two new varieties; as it was about half (50%) from the initial grain weight (Tables 1 and 4). Nogal (4577 kg.ha^{-1}) and Adana-99 (4552 kg.ha^{-1}) varieties significantly produced higher grain yield when compared the two other varieties; also these varieties were superior in above ground biomass yield. Regarding eco-zinc treatments, only final grain yield was significant and was higher when seed soaked in eco-zinc solution (4609 kg.ha^{-1}) as compared to all other treatments. The obtained results for eco-zinc fertilizer are agreed with those of Keram *et al.* (2012; El-Habbasha *et al.* (2015) and Arshad *et al.* (2016). The final grain yield was positively correlated with number of spikes (fertile tillers) (r= 0.52**) and biomass (r= 0.77**); the other correlation between studied measurements are observed in table (5).

The Italian varieties were late in maturity (162 days to maturity) for about 10 day from the local varieties (153 days to maturity) and this was the reason behind extending the grain filling period and match the high temperatures and low rainfall in May (Table 1), while the local varieties were earlier and escaped the stress of high temperatures and low moisture which enabled them to fill the grain more efficiently (Table 4). Borghi *et al.* (1987) described that early maturing wheat varieties with a fast grain filling can reach optimum grain weight.

Table 5. Simple correlation between some studied characteristics.

#	GYLD[1]	HGHT	NSPK	SLGT	SPLSP	SSP	SYSP	SDENS	TGW	FLAR	CHLO	EMER	BIOM
HGHT	0.12 ns												
NSPK	0.52 **	0.22 ns											
SLGT	0.35 ns	0.34 ns	0.27 ns										
SPLSP	0.14 ns	-0.62 **	0.05 ns	0.43*									
SSP	0.02 ns	-0.75 **	-0.12 ns	0.12 ns	0.88**								
SYSP	0.27 ns	-0.18 ns	-0.02 ns	0.24 ns	0.44*	0.61**							
SDENS	-0.19 ns	-0.89 **	-0.19 ns	-0.42*	0.64**	0.79**	0.26ns						
TGW	0.30 ns	0.73 **	0.17ns	0.13 ns	-0.58**	-0.57**	0.30ns	-0.68**					
FLAR	0.05 ns	0.68 **	0.24ns	0.45*	-0.21ns	-0.36 ns	-0.04ns	-0.60**	0.42*				
CHLO	-0.03 ns	-0.19 ns	0.10ns	0.21 ns	0.27ns	0.18 ns	0.18ns	0.12ns	-0.04ns	-0.03ns			
EMER	-0.14 ns	0.67 **	0.02ns	0.13 ns	-0.58**	-0.54**	-0.09ns	-0.65**	0.54**	0.38*	-0.04ns		
BIOM	0.77 **	0.26 ns	0.72**	0.55**	0.20ns	-0.08 ns	0.02ns	-0.29ns	0.16ns	0.35ns	0.15ns	0.01Ns	
HI	0.12ns	-0.26ns	-0.43*	-0.43*	-0.16ns	0.16 ns	0.36ns	0.23ns	0.15ns	-0.49**	-0.24ns	-0.18Ns	-0.54**

[1]GYLD, grain yield; HGHT, plant height; NSPK, number of spikes square meter, SLGH; spike length, SPLSP, number of spikelets per spike, SSP; number of seeds per spike, SYSP; seed yield per spike, SDENS; spike density, TGW; 1000 grain weight, FLAR; flag leaf area, CHLO, leaf chlorophyll; EMER; field emergence percentage, BIOM; biomass.

The grain filling is the most critical stage, any stress during this stage will negatively affect 1000 grain weight and final seed yield (Robertson *et al.*, 2004).

The effect of high temperature and low moisture stress at flowering stage and grain filling stage was also reported by Eichenberger, 2009; Habash *et al.*, 2009; Sangtarash (2010); Passioura (2012) and Omer (2015)and accordingly the wheat cultivars that flower too late are at higher risk of stress that may lead to spike and grain damages and also effect on the stem water soluble carbohydrate remobilization to the grain.

Therefore, both Italian varieties (Zanzibar and Nogal) which were late in maturity are not recommended for the unsecure rainfall areas. On the other hand, supplementary irrigation can suggested and approach to overcome any stress at flowering and grain filling stages.

Conclusion

Based on the results obtained from this study, the two new investigated varieties (Zanzibar and Nogal) which were late in maturity as compared to the local varieties are not recommended to Duhok and similar environments unless an alternative source of supplementary irrigation is available to overcome the low rainfall confliction; the delay maturity for the Italian varieties caused for bad grains qualities and shrinkage of seeds as they exposed to the stress (high temperature) during the grain filling stage in May. Although the final grain yield was increased with the application of eco-zinc fertilizer, the yield components were not enhanced significantly. Therefore, further investigations regarding eco-zinc fertilizer application and more multi-environment tests in different sowing dates for these new varieties to fix their characteristics especially (grains quality) before recommending to the farmers is recommended.

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