Performance of Some Wheat Genotypes Affected By Different Nitrogen, Potassium and Zinc Foliar Applications

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Abstract: For increasing wheat grain yield and protein content for human nutrition, two field experiments were conducted at DirabExperimental and Research Station, College of Food and Agriculture Sciences, King Saud University, for two seasons 2011 and 2012. Four wheat varieties were used in this study. These included the recommended cultivar (YecoraRojo), as well as two advanced lines selected from the wheat breeding program at the Plant Production Department (KSU 105 and L11-21) and the variety Pavon 76 were derived from CIMMYT program. The experimental design was split- plot design with three replications. Varieties were assigned to the main plots and five foliar application treatments: control, N (3 % Urea), K(2 % K_2O), Zn (0.5 % $ZnSO_4.H_2O$) and mix of 3 % urea +2 % K_2O +0.5 % $ZnSO_4H_2O$ were assigned to the sub- plots. Results showed that the newly selected promising lines KSU105 gave the highest plant height, number of spikes /m^2, 1000 kernel weight, grain yield, biologicalyield and grain protein content. On the other hand the promising lines L11 -21 had the highest spike length and spike weight. All foliar applicationshad significant improvements for all characterscomparing with the control. The best significant nutrient foliar treatment was the mixture of N, K, and Zn spray. The highest grain yield and protein content was achieved from the selected promising lines KSU 105 under the mixed foliar application(N+ K+Zn).

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1. Introduction

Wheat (*Triticumaestivum* L.) is considered the most important crop in food security prospective. Wheat is strategic crop since; wheat need in Saudi Arabia is blooming day by day due to population increase. To meet the required demand, more area should be brought under cultivation to increase production. At the same time, limiting water resource and using poor quality water are affecting wheat production, soil sustainability and nutrient availability. Wheat yield can also be increased by the use of recently developed high yielding; abiotic and biotic resistant varieties, irrigation and use of appropriate amounts of macro and micro-nutrients (Nitrogen, Potassium, Zinc etc.) either as a soil or foliar application.

Earlier studies on the improved and elected new genotypes done in Saudi Arabia have shown the superiority of some strains on the trade variety of YecoraRojo. Therefore, strains KSU 102, KSU 105 and KSU 106 significantly exceeded it by more than to 30% (Moustafa *et al.,* 1998, Al-Doss *et al.,* 2004). Furthermore other studies have, shown the superiority of some newly produced strains in the growth and production under conditions of moisture and soil salinity stress (Alderfasi and Moustafa, 2001) which bodes well for the ability of these strains resistant to different environmental conditions in the Kingdom. Mohammad *et al.,*(2008) and Yildirim and Bahar (2010) found great genetic variation between different wheat genotypes tested under various salinity levels regarding the yield and yield components of wheat crop.

Under abiotic stress conditions and fast correction of nutrients deficiency, the foliar application of nutrients is more effective as compared to soil applied nutrients because of effective utilization by plant and minimum cost per unit area (Narang *et al*., 1997). Nitrogen and Potassium are the main macronutrients that are taken by the plants in comparatively large quantities and these are usually deficient in sandy soil and saline soil or under using poor quality water. Thereby, foliage application as foliar spray of these elements is the best method of fertilizer application to control their losses from the soil and make them more and easily available to the plant and in turn increase the yield and quality of wheat grain (Zhiguleve, 1992). Potassium has essential functions in enzyme activation, regulation of clever pH, Cation- anion balance, regulation of transpiration by stomata, and the transport of assimilates Potassium (K) is involved in growth of meristematic tissue and is indispensable for the maintenance of cell turgor pressure, which is required for cell expansion (Rogalski, 1994). The use of K is especially important where high rate of nitrogen and phosphorus are used and when high yield is expected (Defan *et al*., 1999 and Narang *et al*., 1997).

Rajput *et al*., (1995) reported that Zinc (Zn) is also included in key metabolic processes such as respiration, photosynthesis and assimilation of some major nutrients. Zinc has an important role in enzymes activation as well. The efficiency of such type of elements is improved when it is used in combination with other elements like N and K

Hasina *et al.,* (2011) stated that yield and yield components of wheat showed significant response towards foliar spray of Nitrogen, Potassium and Zinc. Maximum biological yield, number of grains spike^{-1} and straw yield were produced in plots under the effect of foliar spray of 0.5% N + 0.5% K + 0.5% Zn solution, while control (no spray) plots produced minimum biological yield, number of grains spike^{-1} and straw yield.. Similarly maximum thousand grain weight and grain yield were recorded in plots sprayed with 0.5% N + 0.5% K + 0.5% Zn solution (twice), followed by lowest values and in plots having no spray (control). Among the treatment of 0.5% N + 0.5% K + 0.5% Zn solution applied either one or three times, gave best response towards yield and yield components of wheat

Keram *et al.,* (2012) found that application of N+K+Zn significantly produced the highest values of yield, yield components and protein content

The present study was conducted to determine the effect of foliar application of Nitrogen, Potassium and Zinc on the growth performance, yield, yield component and grain quality of wheat under Saudi Arabia condition.

2. Materials and Methods

Two field experiments were carried out at the Experimentalfarm of Research Station of Food and Agriculture Sciences College, King Saud University. The experiment was conducted during the two successive winter seasons of 2011 and 2012. The present experiment was performed to study the effect of foliar application of nitrogen, potassium and zinc on the productivity of four wheat genotypesand their proteincontent. The soil texture of experimental sites was loam-sandy whose physiochemical attributes are shown in Table (1).

Table (1): Physical and chemical properties of soil of experimental sites during 2011 and 2012 seasons

Season	EcdS/ m	pH	Cationmq/l			Anion mq/l			texture	OM%
			$Ca^{+2}+Mg^{+2}$	Na^{+}	K^{+}	HCO^{-}	$SO4^{-}$	Cl^{-}		
2011	1.0	7.6	7.9	5.8	0.30	2.1	3.4	4.0	Loamy sand	0.4
2012	1.1	7.6	7.1	5.6	0.32	2.0	4.3	4.5		0.4

Four wheat genotypes were used in this study. Those four studied wheat genotypes included the recommended cultivar (YecoraRojo), two advanced lines selected from the wheat breeding program at the Plant Production Department (KSU 105 and L11-21) and the variety Pavon 76 derived from CIMMYT program. Five foliar application treatments: control (tap water),N (3 % Urea), K (2 % K_2O), Zn (0.5 % $ZnSO_4.H_2O$) and mix of 3 % urea +2 % K_2O +0.5 % $ZnSO_4$ H_2O were tested during the current study.

The experimental design was split- plot design with three replications. Varieties were assigned to the main plots and Nutrient foliar application treatmentswere allocated in the sub- plots. Each plot consisted of 8 rows (20 cm spacing) 3 meterlength. Wheat varieties were planted on 6 and 9 October in 2011 and 2012 seasons respectively, with seed rate of 150 kg /ha.. The spraying treatments were applied three times at 25, 50 and 75 days after sowing. Phosphorus and potassium were added during seed bed preparation at the rate of 200 kg /ha in the form of calcium superphosphate (15.5 %P2O5) and potassium sulfate (48% K_2O), respectively. Nitrogen fertilizer was added at the rate of 200 kg/ hain the form of ammonium sulfate (20.6 % N) in four equal doses (during seed bed preparation, 15, 30 and 45 days after sowing). Standard cultural practices of growing wheat followed by the farmers of this district were adapted.

At harvest sample of one square meter were taken at random from the middle rows of each plot from the three replicates to determine: plant height (cm), number of spikes /m^2, spike weight (g), spike length (cm), 1000 – grain weight (g). Grain and biological yields were determined from the sex inner rows of each an experimental units from then converted to yield per hectare at the basis of moisture content of 14%. Grain protein content was determined according to A.O.A.C. (1965).

Data were subjected to statistical analysis of variance, and means of treatments were compared by LSD at p of 0.05 % level of significance according to Gomez and Gomes (1984).

3. Results and Discussion

Plant height (cm)

Data in Table (2) showed that wheat genotypes exhibited significant variation in their plant height in both seasons of study.KSU105 wheat genotype recorded the tallest plants in the two seasons. The shortest plants were given by YecoraRojo. That mainly attributed to genetic makeup. The analysis of variance (Table-2) indicatedthat plant height had significantly affected by foliar application of N, K and Zn solutions. Maximum plant height was recorded in those plots which were sprayed with mixture of N+K+Zn solution in three times, while minimum plant height was recorded in control (no spray) plots. This might be due to foliar application of N, K and Zn solution to increase the stem length at boot stage which in turn resulted in maximum plant height. These results are in close agreement with those of Rogalski (1994). The interaction between wheat genotypes and different solutions spray didn't exert ant significant effect on plant height in both seasons.

Spike length(cm)

Data listed inTable (2)revealed that wheat genotypes possess significant variation in their plant height in both seasons of study. L11-21wheat genotype had the longest spikes in the two seasons. The shortest panicles were given by Pavon76,that mainly attributed to genetic makeup. The analysis of variance (Table2) confirmed that spike length wassignificantly affected by foliar application of N, K and Zn solutions. The longest spikes wererecorded in those plots which were sprayed with mixture of N+K+Zn solution three times, while minimum spike length was recorded in control (no spray) plots. This might be due to foliar application of N, K and Zn solution to increase the stem length at boot stage which in turn resulted in maximum plant height. These results are in close agreement with those of Rogalski (1994). The interaction between wheat genotypes and different solutions spray didn't exert ant significant effect on spike length in both seasons.

Number of spikes /m^{-2}

The number of spikes/ m^{-2} is given in Table (2). The tested wheat genotypes significantly varied in number of spikes/ m^{-2} as seen in Table2. The maximum numbers of spikes were obtained by pavion-76, without any significant differences with those produced by KSU105 in the first season. In the second season KSU105 gave the highest values of number of spikes/ m^{-2} without any significant differences with those produced by Pavon76.The minimum spike numbers/ m^{-2} were exerted by L11-21 in both seasons. This data confirmed the high capability of both KSU105and Pavon76 wheat genotypes to produce more reproductive tillers(Salem and Al- Doss, 2014).

The analysis of variance showed that foliar spray N,K, Zn assingle ormixture of N+K+Zn had significant effect on the number of spikes/ m^{-2}. Significant improvement in spike numbers/ m^{-2} over control were exhibited by different foliar spray treatment, Furthermore, highest number of spikes/ m^{-2} were obtained from those plots which were sprayed with mixture N+K+Zn solution three times, while minimum number of spikes/ m^{-2} were recorded in plots received none of spray. Spraying N,K and Zn as apart were at the same level of significant regarding spikes number. This might be due to more number of tillers each of which bear more number of spikes, secondly might be due to more balance between C/N ration induced more fertile tiller. These results are completely supported by the findings of Smith *et al.*, (1991) who reported that foliar spray of urea increase the number of spikes. In addition, Hasina *et al.*, (2011) stated that foliar spray of mixture of N+K+Zn solution significantly improved number of spikes/ m^{-2} as a result of improving wheat growth.

Spike weight (g)

The data of spike weight ispresented in Table (3). The studied wheat genotypes differentlyperformed in spike weight. The maximum spike weight was obtained byL11-21. The minimum spike weight was exerted by Pavon76 in both seasons. The data of spike weight showed opposite pattern of spikes number of various wheat genotypes.

The analysis of variance showed that foliar spray N,K, Zn as single or mixture of NK Zn solutions had significant effect on the Pavon76. Significant improvement in spike weight over control were exhibited by different foliar spray treatment, Furthermore, highest spike weight was obtained from those plots which were sprayed with mixture N+K+Zn solution three times, while minimum spike weight were recorded in plots received none of spray.. The possible reason might be due to more accumulation of dry matter in grains with increase application of foliar spray. Furthermore, foliar spray might increase current photosynthesis during grain filling period resulted in filling grain improvement and subsequently, spike weight. The present finding are in accordance with those reported by Rogalski (1994), Mohammad *et al.,* (2008) and Yildirim and Bahar (2010) andSalem and Al- Doss (2014). Hasina *et al.,*(2011) stated that foliar spray of mixture of N+K+Zn solution significantly improved number of spikes m^{-2}as a result of improving wheat growth.

Table 2: Average of plant height, spike length and spike numbers/m^2 of some wheat genotypes as affected by different foliar spray treatments of N, K and Zn in 2011 and 2012 seasons.

Traits	Plant height cm		Spike length cm		Spike numbers/m^{-2}	
Wheat genotypes	2011	2012	2011	2012	2011	2012
Pavon76	89.7b	91.4b	10.7d	11.1d	563.1a	555.5a
YecoraRojo	79.1c	80.0b	12.2c	12.4c	541.8b	533.5b
KSU105	94.7a	95.1a	13.9b	14.4b	563.3a	557.8a
L11-21	78.2c	79.6c	18.1a	18.3a	432.9c	420.3c
F test	**	**	**	**	**	**
Foliar treatments						
Control	80.8c	82.3d	12.4d	12.8d	478.3d	471.3c
N Spray	85.9b	87.6b	13.9b	14.4b	530.7bc	521.1b
Kspray	84.5b	85.5c	13.4c	13.9c	522.1c	513.3b
Zn spray	85.3b	85.8bc	13.7bc	13.9c	536.1b	523.8b
N+K+Znsolution spray	90.7a	91.6a	14.9a	15.2a	559.2a	554.3a
F test	**	**	**	**	**	**
The interaction effect	NS	NS	NS	NS	NS	NS

Thousand grain weight (g)

Data of Thousand grain weigh affected by wheat genotypesis documented in Table 3. The studied wheat genotypes differently performed in spike weight. The heaviest thousand grain weight was obtained by KSU105 in both seasons of study. The lightest thousand grain weight was exerted by Yecora Rojo in both seasons. The obtained variation in thousand grain weight mainly attributed to genetic background. Similar variations in thousand grain weight are reported by Yildirim and Bahar(2010) and Salem and Al- Doss(2014).

Table 3: Average of spike weight, 1000 grain weight and grain yield t/ ha^{-1}of some wheat genotypes as affected by different foliar spray treatments of N, K and Zn in 2011 and 2012 seasons.

Traits	Spike weight(g)		1000grain weight(g)		Grain yield tha^{-1}	
Wheat genotypes	2011	2012	2011	2012	2011	2012
Pavon76	2.75c	2.93c	44.5a	45.2a	7.42b	7.41b
YecoraRojo	2.87bc	3.02b	37.4b	38.5c	5.80d	5.78d
KSU105	2.97b	3.10b	44.6a	45.4a	8.49a	8.38a
L11-21	3.5a	3.58	44.4a	42.9b	6.35c	6.48c
F test	**	**	**	**	**	**
Foliar treatments						
Control	2.65c	2.84d	39.4c	40.2c	6.52c	6.52c
N Spray	3.07b	3.22b	43.0b	43.1b	7.08b	7.05b
Kspray	2.99b	3.03c	42.8b	43.4b	7.04b	6.98b
Zn spray	3.02b	3.18bc	43.3b	43.1b	7.02b	7.07b
NKZn solution spray	3.38a	3.52a	45.2a	45.3a	7.42a	7.44a
F test	**	**	**	**	**	**
The interaction effect	NS	NS	NS	NS	**	**

Table (4). Average of grain yield t /ha^{-1}of wheat as affected by the interaction between genotypes and nutrient foliar spray treatments during 2011 and 2012 seasons.

Foliar treatments	2011				2012			
	Pavon76	YecoraRojo	KSU105	L11-21	Pavon76	YecoraRojo	KSU105	L11-21
Control	6.99	5.36	7.95	5.79	6.91	5.36	7.83	6.02
N Spray	7.47	5.89	8.57	6.37	7.42	5.84	8.42	6.50
Kspray	7.45	5.81	8.50	6.42	7.45	5.57	8.41	6.49
Zn spray	7.40	5.74	8.56	6.37	7.43	5.88	8.50	6.51
N+K+Zn	7.80	6.19	8.89	6.80	7.86	6.25	8.79	6.87
LSD0.05	0.34				0.39			

Data regarding thousand grain weight of wheat as affected by foliar application of N, K and Zn are given in Table 4. Statistical analysis of the data showed that there is significant effect of foliar application of nitrogen, potassium and zinc on thousand grain weight. The mean valves of foliar treatments showed that maximum 1000 grain weight was recorded in plot sprayed with N+K+Zn solution three times; while minimum grain weight was obtained in plots sprayed none of any nutrient. Spraying N,K and Zn as apart were at the same level of significant regarding 1000-grain weight. The possible reason might be dueto more accumulation of dry matter in grains with increase application of foliar spray. These results are also in line with those of Fillipove and Mangova (1992) and Hasina *et al.*, (2011) as they reported that grain weight increased with foliar application with nitrogen and potassium spray but the contrasting results were given by Sud *et al*., (1990) who did not observed any change in 1000 grain weight with increasing nitrogen rate.

Grain yield (t/ ha^{-1})

Data of grain yield affected by wheat genotypes is documented in Table 3. The studied wheat genotypes differently performed in grain yield in both seasons. The highest grainyield was obtained by KSU105 in both seasons of study. The minimum grainyield was exerted by L11-21in both seasons. The KSU105 showed the superiority in grain yield attributed to high spike numbers and heaviest grain. On the hand, the opposite was correct with LI1-21. The current findings are in line with those reported by Yildirim and Bahar(2010) Salem and Al- Doss (2014).

Data regarding grain yield (t ha^{-1}) affected by NKZn foliar application are shown in Table-3. Statistical analysis of the data revealed that significant difference were found among the treatment of foliar application of N, K and Zn for grain yield. Highest grain yield was observed in plot sprayed with N+K+Zn solution three times. The lowest value of grain yield was noted in control (no spray) plots. The possible arguments may be due to split application of foliar spray at certain growth stage particularly at late growth stage increases the grain development and as a result higher grain yield is produced. The present results are in line with the result of Eman and Moqied (1989) as they noticed that foliar application of urea increase the grain yield. The results reported by Narang *et al*., (1997) were also showed that foliar application spray of potassium increase grain yield. These results can also be matched with Zafar and Fayyaz (2007). The current results are in same line with those reported by Hasina *et al*.,(2011). The latter author reported improvements in yield and yield component of wheat as a result of N+K+Zn foliar spray and they reach the maximum values at mixture of N+K+Zn solution spray.

The Interaction between wheat genotypes and foliar spray of N+K+Zn had significant effect on grain yield in both seasons (Table4). The highest grain yield was obtained by KSU105 when it was sprayed with mixture ofN+K+Znsolution while, the minimum grain yield was produced by L11-21 under control treatment in both seasons.

Biological yield (t/ ha^{-1})

Data pertaining to biological yield influenced by wheat genotypes is put inTable5. The studied wheat genotypes significantly differed in their grain yield in both seasons. The maximum biological yield was obtained by KSU105 in both seasons of study. The lowest biological yield was exerted by L11-21in both seasons. The KSU105 showed the superiority biological yield mightbe attributed to high dry matter accumulation. On the hand, the opposite was correct with LI1-21. The current findings are in line with those reported by Yildirim and Bahar(2010) and Salem and Al- Doss(2014.

Biological Yield (t/ ha^{-1}) is given in Table5. The analysis of variance shows that foliar application of N, K and Zn apart or in mixture had significant effect on the biological yield. Mean valves for the foliar application treatments indicate that maximum biological yield was recorded in plots sprayed with mixture of N+K+Zn solution applied three times, while minimum valves was obtained in control (no spray) plots. This might be due to more number of tillers m^{-2} each of which bear more spikes. The results are in agreement with result of Rajput *et al*., (1995) and Hasina et al., (2011) who reported that biological was increased with foliar spray of nitrogen. Dafan et *al*. (1999) also observed the same results. They reported that foliar application of potassium increased the biological yield.

Harvest index

Data regarding to harvest index affected by different wheat genotypes is allied in Table 5. The studied wheat genotypes significantly differed in their harvest index in both seasons. The maximum harvest index was obtained by Yecora Rojo in both seasons of study. The lowest biological yield was exerted by L11-21 in both seasons. The YecoraRojo showed high capability to produce more grain against straw resulted in high harvest index. On the hand, the opposite was correct with LI1-21. The current findings are in line with those reported by Yildirim and Bahar (2010) and Salem and Al- Doss(2014). The analysis of variance shows that foliar application of N, K and Zn apart or in mixture had in significant effect on harvest index in both seasons (Table3).

Protein content%

Data regarding to protein content affected by different wheat genotypes is arranged in Table 5. The tested wheat genotypes significantly differed in their protein in both seasons. The maximum harvest index was produced by KSU105 in both seasons of study. The protein was obtained by Pavon76 in both seasons. The Yecora Rojo showed high capability to produce more grain against straw resulted in high harvest index. On the hand, the opposite was correct with LI1-21. The current findings are similar with those reported by Yildirim and Bahar (2010). Data of protein content of wheat affected by N+K+Zn foliar application are shown in Table-5. Statistical analysis of the data revealed that significant difference were detected among the treatment of foliar application of N, K and Zn as part or in mixture for protein content. Highest protein content was observed in plot sprayed with N+K+Zn solution three times. The lowest value of grain yield was noted in control (no spray) plots. The possible arguments may be due to split application of foliar spray at certain growth stage particularly at late growth stage increase the nitrogen content and as a result higher protein content is produced. The results are in conformity with the findings of Karem *et al*.,(2012).

Table(5): Average of Biological yield t/ ha^{-1}, harvest index and protein content% of some wheat genotypes as affected by different foliar spray treatments of N,K and Zn in 2011 and 2012 seasons.

Traits	Biological yield		Harvest index		Protein content%	
Wheat genotypes	2011	2012	2011	2012	2011	2012
Pavon76	25.5b	25.4b	0.29c	0.29b	10.1c	10.4b
YecoraRojo	16.1d	16.4d	0.36a	0.36a	10.4a	10.5b
KSU105	27.1a	27.8a	0.32b	0.30b	10.9a	10.1a
L11-21	22.8c	23.8c	0.28c	0.28c	10.2bc	10.5b
F test	**	**	**	**	**	**
Foliar treatments						
Control	20.7c	21.7c	0.32	0.31	9.6c	9.9d
N Spray	22.9b	23.2b	0.31	0.31	10.5b	10.9b
K spray	23.0b	23.2b	0.31	0.30	10.2b	10.5c
Zn spray	23.1b	23.5b	0.31	0.31	10.5b	10.4c
NKZn solution spray	24.7a	25.2a	0.30	0.30	11.1a	11.3a
F test	**	**	NS	NS	**	**
The interaction effect	NS	NS	NS	NS	NS	NS

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