Araştırma Makalesi
(Research Article)

Ege Üniv. Ziraat Fak. Derg., 2014, 51 (1): 77-83
ISSN 1018 – 8851

Effect of Zinc Enriched Composed Nitrogen Fertilizer on Some Yield and Quality Parameters of Some Durum Wheat Cultivars (*Triticum durum* Desf.)

Bazı Makarnalık Buğday (*Triticum durum* Desf.) Çeşitlerinin Bazı Verim ve Kalite Özellikleri Üzerine Çinko Katkılı Azotlu Gübrelerin Etkisi

Nesrin ÖRÇEN[1]
Muzaffer TOSUN[1]
Eşref İRGET[2]

[1]Department of Field Crops, Faculty of Agriculture, Ege University, 35100 Izmir/Turkey
e-posta: nesrin.orcen@ege.edu.tr

[2] [1]Department of Soil Science, Faculty of Agriculture, Ege University, 35100 Izmir/Turkey

Alınış (Received):28.08.2013 Kabul tarihi (Accepted): 29.11.2013

Key Words:

Nitrogen form, Grain yield, Grain protein content.

ABSTRACT

Zinc is an essential micronutrient for biological systems because of its role in protein synthesis and metabolism. In this study a field experiment was designed to study the effects of zinc enriched composed nitrogen fertilizer on grain yield and quality in durum wheat (Altar-84, Gediz-75, Ege-88, Kızıltan-91, and Kunduru-1149). The experiments were conducted in split plot arrangement with four replications in Bornova and Menemen locations during two growing seasons. In all the plots, single rate of 16 kg/da N fertilizer was applied with different forms (20-20-0, 20-20-0+Zn and 15-15-15+Zn). Results from analyses of variance indicate that there were significant differences among cultivars in all studied characteristics (grain yield, 1000- kernel weight, test weight, grain protein content, SDS-sedimentation) in all environments. Effect of N fertilizer form on yield, 1000-kernel weight, test weight, grain protein content and SDS-sedimentation, varies depending on year and location. It was concluded that Zn addition led to increased in 1000- kernel weight all of cultivars. Application of N as 15-15-15+Zn form led to higher increase of test weight in compare to 20-20-20+Zn for all cultivars except for Altar-84. The Zn addition to composed N fertilizer had positive effect on average grain protein content of Gediz-75 and Ege-88 in all locations and years.

Anahtar Sözcükler:

Azotlu gübre formu, Dane verimi, Dane protein içeriği

ÖZET

Çinko protein sentezi ve metabolizmadaki rollü sebebiyle, biyolojik sistem için temel bir mikro elementtir. Bu çalışmada makarnalık buğdaylarda (Altar-84, Gediz-75, Ege-88, Kızıltan-91, ve Kunduru-1149) çinko katkılı azotlu gübrelerin dane verimi ve kalitesi üzerine etkilerini belirlemek için bir tarla denemesi planlanmıştır. Deneme Bornova ve Menemen'de iki yıl dört tekerrürlü bölünmüş parseller düzeninde kurulmuştur. Bütün parsellere tek doz azot (16 kg/da) farklı formlarda (20-20-0, 20-20-0+Zn ve 15-15-15+Zn) uygulanmıştır. Varyans analizi sonucuna göre, incelenen bütün özelliklerde (dane verimi, 1000-dane ağırlığı, hektolitre ağırlığı, dane protein içeriği, SDS- sedimantasyon değeri) bütün çevrelerde çeşitler arasında önemli farklılıkların olduğu görülmüştür. Azotlu gübre formunun dane verimine, 1000-dane ağırlığına, hektolitre ağırlığına, dane protein içeriğine, SDS- sedimantasyon değerine etkisi yıla ve lokasyona bağlı olarak değişmiştir. Zn katkılı azotlu gübreler bütün çeşitlerde 1000-dane ağırlığını artırmıştır. Azotlu gübre 20-20-20+Zn formuna göre 15-15-15+Zn formunda uygulandığında, Altar-84 çeşidi dışında bütün çeşitlerde hektolitre ağırlığını artırmıştır. Zn katkılı azotlu gübre Gediz-75 ve Ege-88 çeşitlerinin dane protein içeriklerini bütün lokasyon ve yıllarda artırmıştır.

INTRODUCTION

Zinc is an essential micronutrient for biological systems because of its role in protein synthesis and metabolism. In biological systems Zn is required by the largest number of proteins (Cakmak, 2009). Enrichment (biofortification) of food crops with minerals was used by many researchers (Pfeiffer and McClafferty, 2007; Bouis, 2003; Cakmak et al., 2010). Agronomic biofortification (e.g., fertilizer applications) and plant breeding (e.g., genetic biofortification) is cost-effective agricultural approaches (Cakmak, 2008; White and Broadley, 2009).

Nitrogen fertilizer form, dosage, source, application type, timing, and response of the genotype are marked as important factors affecting N uptake by plants. Therefore, the effective use of N fertilizer is extremely advisable for accumulation of adequate level of protein in wheat kernels. As the energetic cost of synthesizing N fertilizers is very high, N management is an important factor for reducing costs and soil pollution, while at the same time increasing grain yield and quality.

Till now, many studies have been conducted on N fertilizer application. Most of these studies addressed optimal N fertilization rates and timing, generally in the context of intensive wheat management. However, most of the researches mainly focused on bread wheat, despite the importance of durum wheat. Few field studies have dealt with the behavior and responses of durum cultivars to N fertilizers (Lopez-Bellido et al., 2006). There are several factors such as soil, local climate conditions, crop history and other management practices (Lopez-Bellido et al., 2005; Clawson et al., 2006; Pettigrew and Adamczyk, 2006) which make it impossible to prepare a single recommendation for optimal N fertilizer form for all conditions. In this respect, one of the important factors is N response of genotypes. Thus, optimum strategies must be based on regional estimations of nutrients requirement of the crop to achieve maximum potential yield (Polychronaki et al., 2012).

The aim of the present study is to determine the responses of 5 durum wheat cultivars to N fertilizer form and Zn-added in terms of grain yield, 1000-kernel weight, test weight, grain protein content, SDS-sedimentation.

MATERIALS AND METHODS

In present research, the experiments were conducted during two growing seasons (1999-2000 and 2000-2001) in two locations (Bornova and Menemen) using five durum wheat (*Triticum durum* Desf.) cultivars (Altar-84, Gediz-75, Ege-88, Kızıltan-91, and Kunduru-1149) from different origins (Table 1) under rainfed conditions. The field experiments were conducted in experimental field of Department of Field Crops of Ege University, Bornova, İzmir, Turkey and farm of Faculty of Agriculture of the Ege University, Menemen, İzmir, Turkey (38° 25′ N, 27° 09′ E) with clay loam and loamy texture, respectively. Some soil properties of experimental fields are given in Table 2. Soil samples were analyzed for total soluble salt (conductumetric), pH (saturation paste), $CaCO_3$ (calcimetric), organic matter (Walkley-Black), total N (Kjeldahl method), available P (water exctractable) and K (1 N ammonium acetat) (Kacar, 1995, Ryan et al., 1996).

By the way that the organic substance content in Bornova was higher than Menemen location, the soil in the Menemen location has a pH very close to 7. The meteorological data of experimental area for the first and second growing seasons are given in Table 3. The total rain fall in the March and May of the second year had significant decrease in compare with the total rain fall of same months of the first year in both locations. The average temperature in the March month of the second year was higher than the first year in both locations.

Table 1. Origins of cultivars used in the experiment.

No	Variety	Origin
1	Altar-84	CIMMYT
2	Gediz-75	Aegean Agricultural Research Institute
3	Ege-88	Aegean Agricultural Research Institute
4	Kızıltan-91	Field Crop Central Research Institute
5	Kunduru-1149	Eskisehir Agricultural Research Institute

Table 2. Soil Properties of Bornova and Menemen.

Sites	Total Salt (%)	pH	$CaCO_3$ (%)	Organic Matter (%)	Tototal N (%)	Available P (ppm)	Available K (ppm)
Bornova	0.120	7.7	14.8	2.94	0.146	3.0	460
Menemen	0.090	7.2	8.2	1.54	0.098	6.0	304

Table 3. Temperature, rainfall and relative humidity in the experimental locations.

Months	Average Temp. (C)			Total Rainfall (mm)			Relative Humidity (%)		
	1999-2000	2000-2001	Long Term	1999-2000	2000-2001	Long Term	1999-2000	2000-2001	Long Term
				Bornova					
November	14.2	14.0	13.2	44.3	115.4	82.1	56.6	63.6	68.0
December	11.9	10.1	9.9	96.6	33.0	121.3	67.7	62.8	70.0
January	4.9	9.9	8.1	79.3	74.9	109.5	61.4	65.4	68.0
February	7.8	9.4	8.6	92.2	90.3	92.6	61.5	64.0	67.0
March	10.3	15.4	10.7	79.4	15.5	73.0	60.6	60.4	65.0
April	16.8	15.6	15.1	62.3	69.2	47.6	64.3	60.9	62.0
May	21.1	20.8	20.2	2.6	28.7	33.3	51.4	49.3	58.0
June	26.2	26.2	25.1	0.0	13.2	7.8	45.4	42.1	50.0
Tot./Mean	14.2	15.2	13.9	456.7	440.2	567.2	58.6	58.5	63.5
				Menemen					
November	13.4	14.0	13.0	31.6	63.2	77.3	67.1	73.5	62.0
December	11.5	9.5	9.7	89.1	20.7	114.0	77.4	75.3	65.4
January	4.0	9.3	7.8	58.7	70.2	91.8	68.0	77.3	63.5
February	7.9	9.2	8.7	77.9	64.6	71.9	69.3	74.2	61.2
March	9.6	15.4	10.8	66.6	9.3	65.3	67.4	65.3	60.3
April	16.3	15.4	15.0	63.6	51.7	42.4	72.3	68.8	57.2
May	20.1	19.9	19.9	1.5	26.4	26.6	58.9	59.1	54.2
June	25.2	24.9	24.6	0.4	1.8	6.1	46.5	48.2	47.9
Tot./Mean	13.5	14.7	13.7	389.4	307.9	495.4	65.9	67.7	59.0

In all the plots, single rate of 16 kg N/da was applied. Three different compositions of N as 20-20-0, 20-20-0+Zn and 15-15-15+Zn were applied to main plots. The first main plot (20-20-0) did not contain Zn. The amount of Zn which was applied to the second (20-20-0+Zn) and third main plots (15-15-15+Zn) was adjusted as 0.5 kg /da. Each main plot was divided to three subplots (the data related to subplots are not given in the article). The 8 kg of total 16 kg N/da was applied as basal dressing at pre-planting. The remained 8 kg N/da was applied in three different treatments (application type) for each subplot. For first subplot, all 8 kg N/da was applied as ammonium nitrate at stem elongation and no fertilizer was applied at the heading stage; for second subplot, 4 kg N/da at stem elongation and 4kg N/da heading stage as ammonium nitrate; and for third subplot, 4 kg N/da at stem elongation as ammonium nitrate and 4 kg N/da as foliar urea at heading stage. The ammonium nitrate was applied at pre-planting, and stem elongation to soil and urea was applied as foliar with a backpack sprayer at heading stage.

For all plots, the amount of phosphorus was adjusted as 8 kg P/da, and it was applied to soil at pre-planting. The seeding rates were 600 seeds per m^2 for each cultivar. The split plot size was 24 m^2. Wheat was sown using cereal seeder at 4 cm depth with row distance of 20 cm in middle of November. Weed control was done by applying herbicides before stem elongation stage.

Grain yield of each plot was weighed and yield per decare was calculated. For calculating the average thousand grain weight, 4 samples containing 1000 kernels were counted randomly from each subplot and weighed. Test weight was obtained with standard chondrometer. The grain protein concentration was measured according to Kjeldahl method. A factor of 5.7 was used to convert nitrogen concentration to crude protein concentration. Grain protein concentration was expressed on dry weight basis. Sodium dodecyl sulfate (SDS) sedimentation volume test that uses 1 g of flour sample at 14% moisture was performed as an indicator of protein quality (based on Quick and Donnely, 1980).

The experimental design was a split plot model with completely randomized blocks with four replications. The data obtained from all locations in each growing season was analyzed using SAS statistical software and LSD test was used to compare the averages.

RESULTS AND DISCUSSION

Grain yield

The analysis of variance related to the effects of zinc enriched composed nitrogen fertilizer on grain yield of durum wheat is given in Table 4. The difference between fertilizer forms was significant only in Bornova location in second growing season. The cultivar × fertilizer form interactions were significant (P<0.01) except for Menemen location in the first growing season.

Grain yield in both locations in the first year is higher than the second year. The precipitation amount in March, April and May months of the first year which is known as grain-filling period was higher than the same months of the second year. By the way the total precipitation amount in Bornova location for both years were close to each other (456.7 mm and 440.2mm), the rainfall amounts of these months had remarkable difference (144.3 mm in compare with 113.3mm). The Inter-annual yield difference can be referred to the difference in the precipitation amount of these months.

The average yield in Menemen location was higher than Bornova location in both years. The reason for difference in yield of two locations might be related to the difference in the soil texture of these locations. The soil texture of Bornova was clay loam and Menemen's was loamy. At the same time the pH of the Menemen location which was near to 7 might be an effective factor for this result.

Effect of fertilizer form on grain yield varies depending on genotype and environment. Yilmaz et al. (1999) found that the effect of composed fertilizer form on mean yield was significant just in one of three different locations in their study. In a study conducted by Zhanga et al. (2012), application of Zn with or without urea did not affect grain yield or yield components at any location. According to Ghasemi et al. (2013), the Zn added foliar fertilizer can be used for improving grain yield.

Thousand Kernel Weight (TKW)

While N fertilizer form had significant ($p<0.01$) effect on thousand kernel weight in Bornova location, it was found that there was no significant effect in Menemen location. In all locations there were significant differences ($p<0.01$) among the varieties in TKW (Table 4).

The cultivar x N fertilizer form interaction in Bornova location in both growing seasons was significant and this indicates that the difference between TKW in cultivars in this location is not only depends on genotypic differences, but also to forms of N fertilizer.

In regard to cultivars, it can be seen that Zn added fertilizer increased TKW of Altar-84 and Ege-88 cultivars (Figure 1). Contrary to present study, Özbek and Özgümüş (1998) found that Kunduru-1149 is more responsible to the zinc added fertilizer than other cultivars. Kalaycı (1999) stated that zinc added fertilizer has less effect on durum cultivars compared with bread wheat cultivars. Özbek and Özgümüş (1998) declared that zinc added fertilizer led to %4.5 increase in TKW of Kunduru-1149 and two bread wheat cultivars in compared with control group. So, it can be stated that Zn added fertilizer affect varies depending on environmental condition. Also, Gültekin et al. (2001) reported that TKW of Kızıltan-91 increased just in one location with topdressing of Zn added fertilizer, while decrease in TKW was observed in other locations.

Test weight

The analysis of variance (ANOVA) for test weight of durum wheat related to form is given in Table 4. The differences in test weight were seen between cultivars. While the effect of Zn addition to fertilizer was not significant on test weight in all locations and years, cultivar x fertilizer form interaction was significant only in second growing seasons in Menemen location. Cultivar x fertilizer form x fertilizer timing interaction was significant in second growing season in Bornova location.

Zinc addition to N fertilizer had no meaningful effect on average test weight. Application of N as 15-15-15+Zn form increased the test weight of cultivars more than 20-20-20+Zn of all except for Altar-84 cultivar (Figure 1).

Grain protein content

The effects of Zn addition and N fertilizer form on grain protein is given in Table 4. It can be seen from Table 4 that there are significant differences ($p < 0.01$) between grain protein content of cultivars in different years and locations. Nitrogen fertilizer form had no effect on grain protein content except for in the first growing year in Bornova location. It could be said that the effect of N fertilizer form on grain protein content depends on environmental conditions. Cultivar x fertilizer form interaction was significant in first growing seasons in Bornova and second growing seasons in Menemen locations. So, it can be express that N fertilizer management could have an effect on grain protein content.

The grain protein content in the second growing year for both locations was higher than first growing year of experiments. The lower total rain fall and higher average temperature in March and May months (which are the grain filling seasons) of the second year, might be the two effective factors which might lead to such result.

Although the precipitations amount for second year were too close to each other for both locations, the protein content of grain in the Bornova location was higher than Menemen. This difference can be related to the higher organic substance and nitrogen amount of Bornova soil in compare with Menemen.

Soil quality might get more importance role in protein content when the precipitation is low.

The Zn addition to composed N fertilizer had no positive effect on average grain protein content in all locations and years. There are some researches that have similar results with present study (Gezgin et al., 1999; Gültekin et al., 2001; Kınacı, 1998). Grain protein content of Ege-88 and Gediz 75 have tends to increase by Zn addition (Figure 1).

SDS-Sedimentation

The sedimentation value is known as characterization factor for the swelling capacity of gluten. The SDS-sedimentation value of cultivars in both years and locations had significant differences (Table 4). The difference in N fertilizer forms was found significant only in second year in Menemen location.

Considering the effect of Zn on average SDS-sediment value of five durum wheat cultivars, it can be inferred that it did not have any positive effect on average SDS-sedimentation value of both years (Figure 1). Also, in compare to normal N fertilizer application, Zn added N fertilizer (20-20-0 +Zn) application led to remarkable decrease in SDS-sedimentation value in Menemen location in the second growing year of experiment. Nevertheless, cultivar x fertilizer form interaction was found significant as in the first growing season in Menemen and in the second growing season in Bornova locations. Also, it can be inferred that the effect of Zn added fertilizer on SDS-sedimentation value depends on cultivars. For example, in the first year of experiments Zn added 20-20-0 fertilizer led to significant increase in SDS-sedimentation value in Kunduru-1149. However, Zn applications had no significant impact on SDS-sedimentation value of Kızıltan-91 cultivar in all locations. Also, Gultekin et al. (2001) expressed that application of Zn had no effect on SDS-sedimentation value of Kızıltan-91 cultivar. Zn addition had positive effect on sedimentation value of only Altar-84 in the both years and locations. Kınacı (1998) stated that Zn application had remarkable positive effect on sedimentation value of only one of the three bread wheat cultivars.

Considering the SDS-sedimentation of each cultivar based on location and years, it was noticed that also the location might have effect on the SDS-sedimentation value of cultivars (results not shown). Likewise, Peterson et al. (1992) observed variability in SDS-sedimentation value of 18 winter wheat cultivars and they reported that SDS-sedimentation value's dependence on environmental conditions is more than its dependence on the genetic factors.

Table 4.Yield, 1000 kernel weight, test weight, grain protein content and SDS-sedimentation.

	Bornova									
	Yield (kg/da)		**1000 kernel weight** (g)		**Test weight** (kg)		**Grain protein** (%)		**SDS sedimentation** (mL)	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Frt. form (F)										
20-20-0	383.8	209.2	40.5	34.5	78.5	80.9	12.2	15.5	39.1	25.6
20-20-20+Zn	366.8	216.9	38.9	35.3	77.9	80.9	11.9	15.5	40.6	25.5
15-15-15+Zn	386.9	235.1	40.7	36.7	78.3	81.2	12.6	15.1	39.8	25.8
LSD	NS	3.7	1.2	1.4	NS	NS	0.5	NS	NS	NS
Significance										
F	NS	**	**	**	NS	NS	*	NS	NS	NS
Cultivar (C)	**	**	**	**	**	**	**	**	**	**
C x F	**	**	NS	**	NS	NS	**	NS	NS	*
	Menemen									
Frt. form (F)										
20-20-0	507.7	328.9	44.9	42.0	77.1	77.0	13.2	13.5	33.9	17.5
20-20-20+Zn	509.2	328.8	44.1	41.6	77.0	76.7	13.2	13.3	34.0	16.2
15-15-15+Zn	525.2	321.5	44.8	41.3	77.2	76.9	12.9	13.3	31.9	17.7
LSD	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.8
Significance										
F	NS	NS	NS	NS	NS	NS	NS	NS	NS	**
Cultivar (C)	**	**	**	**	**	**	**	**	**	**
C x F	NS	**	NS	**	NS	**	NS	**	*	NS

*** Significant at the 0.05 level**
**** Significant at the 0.01 level**

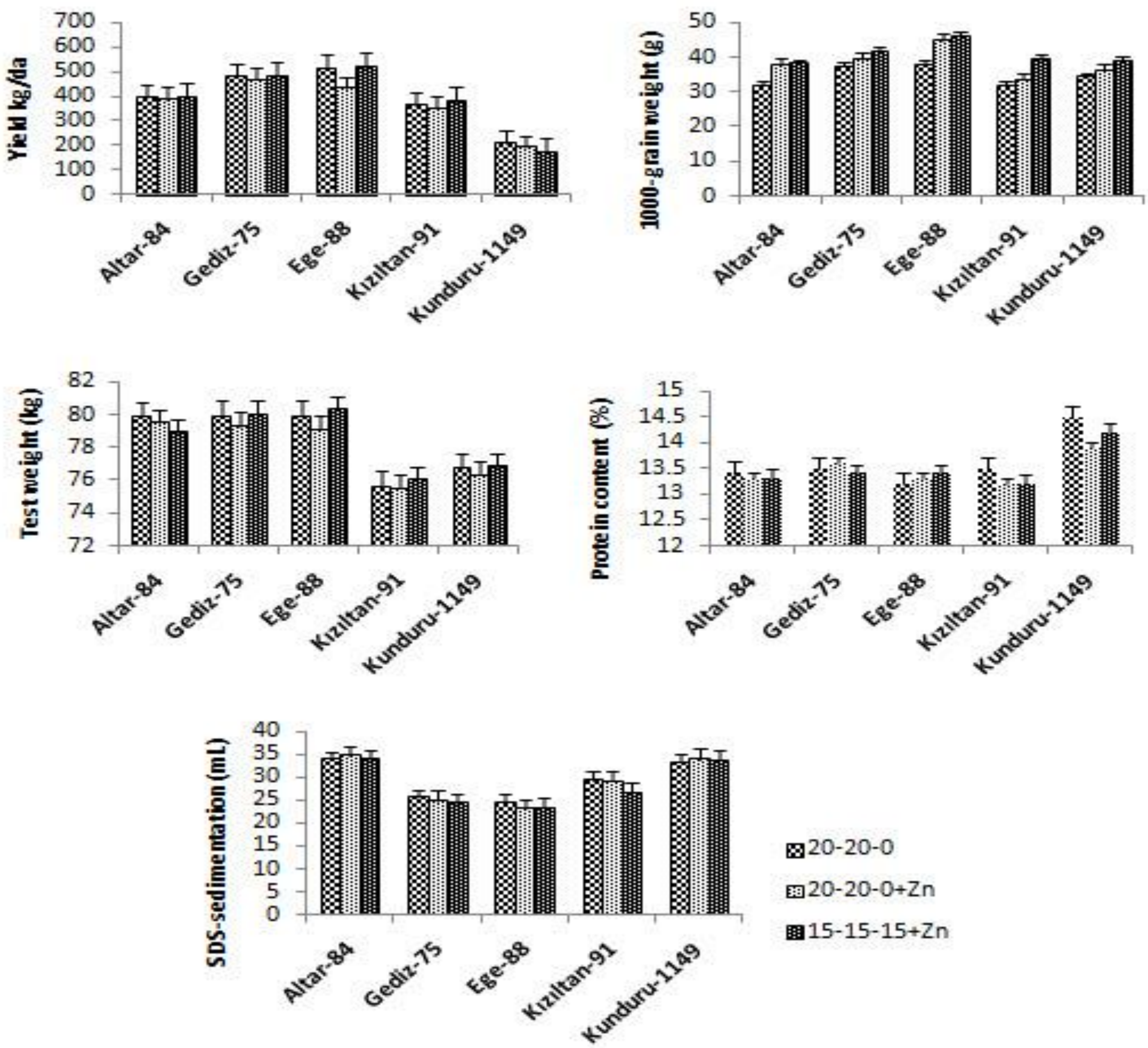

Figure 1. Effect of zinc enriched composed nitrogen fertilizer on some physical and chemical properties of durum wheat cultivars.

CONCLUSION

Zinc added compound fertilizer led to increase in thousand kernel weight of all cultivars. Application of N as 15-15-15+Zn form was more effective than 20-20-20+Zn on the test weight of all cultivars except for Altar-84 cultivar. The Zn addition to composed N fertilizer had positive effect on average grain protein content of Gediz-75 and Ege-88 in all locations and years. Zn addition had positive effect on SDS-sedimentation value of Altar-84 and Kunduru-1149 over years and locations.

ACKNOWLEDGEMENTS

The work was supported by the Scientific and Technical Research Council of Turkey (TUBITAK).

REFERENCES

Bouis, H.E., 2003. Micronutrient fortification of plants through plant breeding: Can if improve nutrition in man at low cost? P. Nutr. Soc., 62(2): 403-411.

Cakmak I., 2009. Biofortification of cereal grains with zinc by applying zinc fertilizers, BioZoom (1) 2–7.

Cakmak, I., 2008. Enrichment of cereal grains with zinc: Agronomic or genetic biofortification? Plant Soil, 302: 1-17.

Cakmak, I., W.H. Pfeiffer, B., McClafferty, 2010. Biofortification of durum wheat with zinc and iron. Cereal Chem., 87: 10-20.

Clawson, E.L., J.T. Cothren, C.D. Blouin, 2006. Nitrogen fertilization and yield of cotton in ultra-narrow and conventional row spacings. Agron. J. 98:72-79.

Gezgin, S., N. Dursun, M. Hamurcu, 1999. Farklı fosforlu gübre ve çinko dozlarının ekmeklik ve makarnalık buğday çeşitlerinin verim ve verim unsurlarına etkileri. Orta Anadolu'da hububat tarımının sorunları ve çözüm yolları sempozyumu, Konya. 249-258.

Ghasemi, S., A.H. Khoshgoftarmanesh, M. Afyuni, H. Hadadzadeh, 2013. The effectiveness of foliar applications of synthesized zinc-amino acid chelates in comparison with zinc sulfate to increase yield and grain nutritional quality of wheat. Eur. J. Agron. 45:68-74.

Gültekin, İ., A. Yılmaz, H. Ekiz, R.Z. Arısoy, M. Şahin, Y. Kaya, 2001. Çinko noksanlığı görülen orta Anadolu topraklarında uygulanan çinko ve kükürt'ün buğdayın verim, verim komponentleri ve bazı kalite özelliklerine ekisi. Türkiye 4. Tarla Bitkileri Kongresi, Tekirdağ, Cilt 1. 129-133.

Kacar, B., 1995. Toprak ve bitkinin kimyasal analizi III. Toprak analizi, A.Ü. Zir. Fak. Egitim Araştırma Geliştirme Vakfı, Yayın No:3 Ankara.

Kalaycı, M., 1999. Yetiştirme tekniği açısından Türkiye buğday tarımının dünü, bugünü, yarını, Orta Anadolu'da hububat tarımının sorunları ve çözüm yolları sempozyumu, Konya. 14-25.

Kinaci, G., 1998. Değişik çinkolu preparatların bazı buğday çeşitlerinde verim, verim öğeleri ve kalite üzerine etkileri. I. Ulusal Çinko Kongresi. 251-256.

Lopez-Bellido, L., R.J. Lopez-Bellido, F.J. Lopez-Bellido, 2006. Fertilizer nitrogen efficiency in durum wheat under rainfed mediterranean conditions: effect of split application. Agron. J. 98:55-62.

Lopez-Bellido, L., R.J. Lopez-Bellido, R. Redondo, 2005. Nitrogen efficiency in wheat under rainfed Mediterranean conditions as affected by split nitrogen application. Field Crop. Res. 94:86-97.

Özbek, V., A. Özgümüş, 1998. Farklı çinko uygulamalarının değişik buğday çeşitlerinin verim ve bazı verim kriterleri üzerine etkileri, 1. Ulusal Çinko Kongresi. Eskişehir. 183-190.

Peterson, C.J., R.A. Graybosch, P.S. Beazinger, A.W. Grombacher, 1992. Genotype and environment effects on quality characteristics of hard red winter wheat. Crop Sci. 32, 98-103.

Pettigrew, W.T., J.J. Adamczyk, 2006. Nitrogen fertility and planting date effects on lint yield and Cryl Ac (Bt) endotoxin production. Agron. J. 98:691-697.

Pfeiffer, W.H., B. McClafferty, 2007. Harvest plus: Breeding crops for better nutrition. Crop Sci., 47: 88-105.

Polychronaki, E., C. Douma, C. Giourga, A. Loumou, 2012. Assessing nitrogen fertilization strategies in winter wheat and cotton crops in Northern Greece. Pedosphere 22(5):689-697.

Quick, J.S., B.J. Donnely, 1980. A rapid test for estimating durum wheat gluten quality, Crop Sci., 20: 816-818.

Ryan, J., S. Garabet, K. Harmsen, A. Rashid, 1996. A Soil and Plant Analysis Manual Adapted for the West Asia and North Africa RegionICARDA, Aleppo, Syria, 140 pp.

White, P.J. and M.R. Broadly, 2009. Biofortification of crops with seven mineral elements often lacking in human diets: Iron, zinc, copper, calcium, magnesium, selenium and iodine. New Phytologist, 182: 49-84.

Yılmaz, A., İ. Gültekin, R.F. Arısoy, 1999. Ekimde tohumla birlikte tohum yatağına uygulanan kompoze gübrelerin hububat, çimlenme, çıkış ve verimine etkileri. Orta Anadolu'da hububat tarımının sorunları ve çözüm yolları sempozyumu, Konya. 189-195.

Zhanga, Y.Q., Y.X. Sunb, Y.L. Yec, M.R. Karima, Y.F. Xuea, P. Yana, Q.F. Menga, Z.L. Cuia, I. Cakmak, F.S. Zhanga, C.Q. Zou, 2012. Zinc biofortification of wheat through fertilizer applications in different locations of China. Field Crop Res. 125:1-7.