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# Effect of Zinc Applications on Quality Parameters of Wheat in Semi Arid Region

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Effect of zinc application methods on 1000 kernel weight, protein content, sedimentation, gluten, gluten index and starch damaged of wheat was studied. Zinc applied to soil, to seed, to leaf, to soil+ leaf and to seed+leaf. Experimental design was factorial in randomized complete block with three replications. Investigated traits affected positively by all zinc treatments. Soil + leaf and soil application of zinc were most effective. Variation observed among wheat genotypes in response to zinc.

**Key Words: Wheat, Zinc applications, Protein content, Sedimentation value, Gluten, Gluten index.**

## INTRODUCTION

Zinc is an essential element for plants, besides for normal development and function of humans and domesticated animals. Approximately 40 % of the world's population suffers from micronutrient deficiencies including zinc deficiency[1]. High consumption of cereal-based food is suggested to be one major reason for zinc deficiency in humans especially in developing countries[2].

Turkey is one of the major wheat producing and consuming countries in the world. Soils of its largest wheat producing area (Central Anatolia) are highly calcareous and low in organic matters. These soil factors limits mobility and availability of soil-zinc or fertilizer-zinc to plant roots[3]. More than 90 % of soils sampled in Central Anatolia contained less than 0.5 mg $kg^{-1}$ DTPA-extractable zinc[4,5].

Zinc deficiency can be make up by applying zinc to soil or plant foliage as well as by treating seeds with zinc. Mengel[6], Schulte and Walsh[7], Fernster *et al.*[8], Martens and Westermann[9] suggested that foliar application of $ZnSO_4$ would improve crop yields. Seed treatment procedures have been tried in an attempt to correct zinc deficiencies. The effect of different zinc application methods on plant grown in zinc-deficient soils was mostly studied on corn, rice, bean, vegetables, fruit trees and wheat[9-11].

The object of this study were to asses the impact of zinc on quality traits and determine the quality differences in wheat genotypes under different zinc application methods.

## EXPERIMENTAL

The grain samples used in this study were obtained from a field experiment conducted by Yilmaz *et al.*[10], as factorial in randomized complete block design with three replications at the research farm of Bahri Dagdas International Winter Cereal Research Center at Konya, in Central Anatolian Region of Turkey to investigate efficient Zn application methods on wheats. Zinc was applied on three wheat cultivars, soft white Gerek 79, hard white Dagdas 94 and hard red Bezostaja 1 as (1) Control (C) (no zinc application), (2) sprayed to soil (3) sprayed on seed, (4) sprayed on to leaves (5), soil + leaf application (methods 2 and 4 combined) and (6) seed + leaf application (methods 3 and 4 combined).

The samples from each plots evaluated for 1000 kernel weight (TKW), protein content (PC), sedimentation value (SV), gluten (GL), gluten index (GI) and starch damaged (SD).

Thousand kernel weight determined by counting 100 grains three times and multiplying their average by 10. Samples were individually milled by laboratory mill and sieve for 1.5 min. Flour moisture was determined (130 ºC for 1 h). Flour protein content was estimated by the NIR analysis using a Dickey-John GAC III previously calibrated against Kjeldahl protein (N × 5.7) determination (AACC, 1983, Method 46-11)[12]. Estimation of sedimantation values was done by AACC, 1983, Method 56-61A[12], gluten and gluten index by AACC Method 38-12[12] and starch damaged by AACC, 1983, Method 76-30 A[12]. SV values evaluated as follows: less than 15 mL is weak, 16-24 mL is medium, 25-36 mL is strong and over 36 is very strong gluten[13]. 27 g and above accepted as high in gluten less than 20 g as low in gluten while 90 % accepted as high gluten index and less than 50 % as low gluten index[14]. Analysis of variance conducted for individual years and data combined over years for factorial design. Relationships between control and zinc application described by regression analysis.

## RESULTS AND DISCUSSION

Analysis of variance (ANOVA) on quality data are presented in Table-1. Combined analysis over the years showed that years, varieties and treatments were significant ($p < 0.01$) for all parameters. Results of the across years analysis (Table-2) indicate that zinc application improved all of the measured parameters significantly. Similar results have been reported by Kelarestaghi *et al.*[15] for protein percentage. The soil + leaf application of zinc was most effective among the treatments followed by soil application. Increase by soil + leaf treatment of two years average were 4.6 % in TKW, 6.5 % in PC, 33 % SV, 13.3 % in GL, 10.9 % GI, 7.9 % SD (Table-2).

Important differences in zinc efficiency among bread wheat cultivars reported by Shukla and Raj[16], Graham *et al.*[17], Rengel and Graham[18], Çakmak *et al.*[19]. In this study, significant differences recorded among varieties for the studied parameters after Zn treatments. Variations among cultivars changed from 0.3 % to 48.4 % in

TABLE-1
SOURCE OF VARIATION, MS AND F-TEST FOR DIFFERENT QUALITY CHARACTERS OF WHEAT GENOTYPES IN COMBINED ANALYSIS OVER THE YEARS (1994-1995 AND 1995-1996)

| | | ANOVA | | | | | |
|---|---|---|---|---|---|---|---|
| | | TKW | PC | SV | GL | GI | SD |
| Replication (R) | 2 | 0.10 | 0.02 | 0.04 | 0.07 | 0.35 | 0.010 |
| Years (Y) | 1 | 126.60‡ | 12.34‡ | 592.68‡ | 133.34‡ | 555.79‡ | 21.870‡ |
| Varieties (V) | 2 | 228.40‡ | 26.01‡ | 1707.82‡ | 988.24‡ | 18042.56‡ | 88.520‡ |
| Treatment (T) | 5 | 11.60‡ | 1.05‡ | 84.48‡ | 56.95‡ | 62.57‡ | 1.720‡ |
| Y X V | 2 | 4.70‡ | 0.84‡ | 136.93‡ | 0.08 | 49.84‡ | 1.530‡ |
| Y X T | 5 | 0.80 | 0.01 | 0.56† | 0.44 | 2.12‡ | 0.050‡ |
| V X T | 10 | 1.30‡ | 0.04† | 0.52‡ | 0.40 | 0.43 | 0.020‡ |
| Y X V X T | 10 | 0.40 | 0.03 | 0.18 | 0.30 | 0.44 | 0.030‡ |
| Error (E) | 70 | 0.40 | 0.02 | 0.18 | 0.22 | 0.42 | 0.002 |

TKW = Thousand kernel weight, PC = Protein content, SV = Sedimentation value, GL = Gluten, GI = gluten index, SD = Starch damaged.

TABLE-2
EFFECTS OF TREATMENT AND INCREASE IN QUALITY CHARACTERS IN YEARLY AND POOLED ANALYSES (1995 AND 1996) ACROSS VARIETIES

| | Year | Treatments | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | IN | 3 | IN | 4 | IN | 5 | IN | 6 | IN |
| TKW | 1995 | 37.9 | 38.9 | 2.6 | 38.3 | 2.6 | 38.0 | 0.3 | 39.5 | 4.2 | 38.7 | 2.1 |
| | 1996 | 39.6 | 41.5 | 4.8 | 40.2 | 1.5 | 40.0 | 1.0 | 42.3 | 6.8 | 40.8 | 3.0 |
| | Comb. | 38.8 | 40.2 | 3.6 | 39.2 | 1.0 | 39.0 | 0.5 | 40.9 | 4.6 | 39.7 | 2.3 |
| PC | 1995 | 10.3 | 10.8 | 9.7 | 10.6 | 2.9 | 10.4 | 1.0 | 11.0 | 6.8 | 10.7 | 3.9 |
| | 1996 | 11.0 | 11.5 | 9.1 | 11.3 | 2.7 | 11.2 | 1.8 | 11.7 | 6.4 | 11.3 | 2.7 |
| | Comb. | 10.7 | 11.2 | 4.7 | 10.9 | 1.9 | 10.8 | 0.9 | 11.4 | 6.5 | 11.0 | 2.8 |
| SV | 1995 | 15.7 | 19.7 | 26.0 | 17.3 | 10.2 | 16.6 | 5.7 | 21.1 | 34.4 | 18.7 | 19.1 |
| | 1996 | 20.2 | 24.4 | 20.8 | 22.0 | 8.9 | 21.0 | 4.0 | 26.4 | 31.0 | 23.0 | 13.9 |
| | Comb. | 17.9 | 22.1 | 23.5 | 19.7 | 10.1 | 18.8 | 5.0 | 23.8 | 33.0 | 20.8 | 16.2 |
| GL | 1995 | 34.0 | 37.8 | 11.2 | 36.0 | 5.9 | 35.1 | 3.2 | 38.8 | 14.1 | 36.8 | 8.2 |
| | 1996 | 36.6 | 40.2 | 9.8 | 37.8 | 3.3 | 37.0 | 2.7 | 41.1 | 12.3 | 39.1 | 2.7 |
| | Comb. | 35.3 | 39.0 | 10.5 | 36.9 | 4.5 | 36.1 | 2.3 | 40.0 | 13.3 | 37.9 | 7.4 |
| GI | 1995 | 44.0 | 46.9 | 6.6 | 45.1 | 2.5 | 44.4 | 0.9 | 48.2 | 9.5 | 46.0 | 4.5 |
| | 1996 | 47.3 | 52.0 | 9.9 | 50.0 | 5.7 | 48.6 | 2.7 | 53.1 | 12.3 | 51.0 | 7.8 |
| | Comb. | 45.7 | 49.4 | 8.1 | 47.5 | 3.9 | 46.5 | 1.8 | 50.7 | 10.9 | 48.5 | 6.1 |
| SD | 1995 | 11.0 | 11.6 | 5.5 | 11.4 | 3.6 | 11.3 | 2.7 | 11.7 | 6.4 | 11.5 | 4.5 |
| | 1996 | 11.8 | 12.6 | 6.8 | 12.2 | 3.4 | 12.0 | 1.7 | 12.8 | 8.5 | 12.4 | 5.1 |
| | Comb. | 11.4 | 12.1 | 6.1 | 11.8 | 3.5 | 11.7 | 2.6 | 12.3 | 7.9 | 11.9 | 4.4 |

Comb. = Combined; IN = Increase (%).

general (Table-3). According to results of combined analysis, cultivar Bezostaja 1 exhibited maximum TKW (42.8 g), PC (12.4 %), SV (31.2 mL), G (45.9 %) and GI (76.2) values under soil + leaf application, while significant increase recorded for SV, GL, GI values in cultivar Gerek 79 with same treatment. Althought Bagci *et al.*[5] reported some decrease SD with Zn application to soil, all Zn treatments used in this

TABLE-3
GENOTYPIC DIFFERENCES AND INCREASE IN QUALITY TRAITS IN COMBINED ANALYSES

| | Variety | Treatments | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | IN | 3 | 4 | IN | 5 | IN | 6 | IN |
| TKW | GRK | 36.3 | 37.0 | 1.9 | 36.6 | 36.4 | 0.3 | 37.6 | 3.6 | 36.7 | 1.1 |
| | DDS | 40.5 | 41.9 | 3.5 | 41.2 | 40.8 | 0.7 | 42.3 | 4.4 | 41.7 | 3.0 |
| | BEZ | 39.6 | 41.8 | 5.3 | 39.9 | 39.7 | 0.3 | 42.8 | 8.1 | 40.8 | 3.0 |
| PC | GRK | 9.8 | 10.3 | 4.9 | 10.2 | 10.0 | 1.7 | 10.5 | 6.1 | 10.3 | 4.4 |
| | DDS | 10.7 | 11.1 | 3.3 | 10.9 | 10.8 | 0.8 | 11.2 | 5.1 | 11.0 | 2.3 |
| | BEZ | 11.5 | 12.1 | 5.1 | 11.8 | 11.6 | 0.9 | 12.4 | 7.8 | 11.9 | 3.5 |
| SV | GRK | 12.4 | 16.7 | 34.7 | 13.5 | 12.7 | 2.4 | 18.4 | 48.4 | 15.0 | 21.0 |
| | DDS | 16.0 | 20.0 | 25.0 | 18.0 | 17.0 | 6.0 | 22.0 | 37.0 | 19.0 | 19.0 |
| | BEZ | 25.5 | 29.5 | 15.7 | 27.5 | 26.7 | 4.7 | 31.2 | 22.4 | 28.5 | 11.8 |
| GL | GRK | 31.4 | 35.4 | 12.7 | 33.0 | 31.9 | 3.2 | 36.2 | 15.3 | 34.0 | 8.3 |
| | DDS | 33.5 | 36.7 | 8.7 | 34.9 | 34.3 | 2.4 | 37.9 | 13.1 | 35.7 | 6.6 |
| | BEZ | 41.0 | 45.0 | 9.8 | 42.9 | 42.0 | 2.4 | 45.9 | 12.0 | 44.2 | 7.8 |
| GI | GRK | 29.0 | 33.2 | 14.5 | 31.2 | 30.0 | 3.4 | 34.5 | 19.0 | 32.2 | 11.0 |
| | DDS | 37.0 | 40.2 | 8.6 | 38.2 | 37.7 | 1.9 | 41.4 | 11.9 | 39.2 | 5.9 |
| | BEZ | 71.0 | 75.0 | 5.6 | 73.2 | 71.9 | 1.3 | 76.2 | 7.3 | 74.2 | 4.5 |
| SD | GRK | 9.8 | 10.4 | 6.1 | 10.1 | 10.0 | 2.0 | 10.5 | 7.1 | 10.2 | 4.1 |
| | DDS | 12.8 | 13.5 | 5.5 | 13.2 | 13.1 | 2.3 | 13.7 | 7.0 | 13.4 | 4.7 |
| | BEZ | 11.6 | 12.4 | 6.9 | 12.1 | 11.9 | 2.6 | 12.6 | 8.6 | 12.2 | 5.2 |

Combined over 2 years.

study significantly enhanced SD values. Highest effects were obtained by soil and soil + leaf applications 'variety × treatment' interaction supported that zinc effect on quality traits was varied in relation with genotypes.

Regression analysis showed that variations in quality parameters accounted to zinc application changed from 79 to 99 %. Variation in TKW due to zinc treatments was 79-94 % and highest increase produced by soil + leaf treatment as 125 %. The 91-98 % of variation in PC accounted for zinc treatments. Variation in SV due to zinc application was 97-99 %. According to the regression analysis, 97-100 % of variation in G, GI and SD can be explained by zinc treatment (Table-4).

## Conclusion

Zinc deficiency is a particularly widespread in cereal-growing areas, leading to severe depression in production and nutritional quality of grains[17,20]. Wheat genotypes investigated in this research effected by zinc application and values of quality traits increased in various levels. Hard red Bezostaja 1 and hard white Dagdas 94 gave better response to zinc application in compare with soft white Gerek 79. Variations among wheat genotypes to Zn application my use by breeders to improve germplasm and/or varieties with various quality levels requested by users. According to the result of this study soil + leaf application was the most effective method to obtain

TABLE-4
RELATIONSHIPS BETWEEN CONTROL AND OTHER TREATMENTS (2, 3, 4, 5, 6) IN ALL GENOTYPES

| | | Y = a + bx | R | r |
|---|---|---|---|---|
| Thousand Kernel weight | Control-Soil | 40.2 + 1.22x | 0.85 | 0.92 |
| | Control-Seed | 39.2 + 1.04x | 0.94 | 0.97 |
| | Control-Leaf | 39.0 + 1.01x | 0.92 | 0.96 |
| | Control-Soil + Leaf | 40.9 + 1.25x | 0.82 | 0.91 |
| | Control-Seed + Leaf | 39.7 + 1.10x | 0.79 | 0.89 |
| Protein content | Control-Soil | 11.2 + 0.99x | 0.93 | 0.97 |
| | Control-Seed | 11.0 + 0.91x | 0.96 | 0.98 |
| | Control-Leaf | 10.8 + 0.94x | 0.98 | 0.99 |
| | Control-Soil + Leaf | 11.4 + 1.11x | 0.92 | 0.96 |
| | Control-Seed + Leaf | 11.0 + 0.91x | 0.91 | 0.95 |
| Sedimantation value | Control- Soil | 22.1 + 0.98x | 0.99 | 0.99 |
| | Control-Seed | 19.6 +1.03x | 0.98 | 0.99 |
| | Control-Leaf | 18.8 + 1.02x | 0.97 | 0.99 |
| | Control-Soil + Leaf | 23.8 + 1.0x | 0.97 | 0.99 |
| | Control-Seed + Leaf | 20.8 + 1.0x | 0.98 | 0.99 |
| Gluten | Control- Soil | 39.0 + 1.02x | 0.98 | 0.99 |
| | Control-Seed | 36.9 + 1.0 x | 0.98 | 0.99 |
| | Control-Leaf | 36.1 + 1.01x | 0.97 | 0.99 |
| | Control-Soil + Leaf | 40.0 + 1.0 x | 0.98 | 0.99 |
| | Control-Seed + Leaf | 37.9 + 1.05x | 0.97 | 0.99 |
| Gluten index | Control- Soil | 49.4 + 1.0x | 0.98 | 0.99 |
| | Control-Seed | 47.5 + 1.01x | 0.99 | 0.99 |
| | Control-Leaf | 46.5 +1.0x | 0.99 | 0.99 |
| | Control-Soil + Leaf | 50.6 + 1.0 x | 0.98 | 0.99 |
| | Control-Seed + Leaf | 48.5 + 1.01x | 0.99 | 0.99 |
| | Control- Soil | 12.1 + 1.03x | 0.99 | 0.99 |
| | Control-Seed | 11.8 + 1.06x | 0.99 | 0.99 |
| | Control-Leaf | 11.7 + 1.03x | 1.00 | 1.00 |
| | Control-Soil + Leaf | 12.3 + 1.09x | 0.99 | 0.99 |
| | Control-Seed + Leaf | 12.0 + 1.10x | 0.98 | 0.99 |

considerably high level of quality in bread wheats. Yilmaz *et al.*[10] were found that irrespective of the method, zinc application significantly increased grain yields in all wheat cultivars with the consideration of these two results it can be conclude that zinc application in deficient soils is highly benefical to obtain high quality and high yield from winter wheats.

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