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Full Length Research Paper

The effect of zinc application methods on seed cotton yield, lint and seed quality of cotton (*Gossypium hirsutum* L.) in east Mediterranean region of Turkey

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The effect of different zinc application methods on seed cotton yield, yield components, lint and seed quality of cotton was investigated under east Mediterranean region conditions (Kahramanmaras, Turkey) in 2008. Experimental design was split plots with three replications. The cotton varieties: Agdas-3, Agdas-17 and Maras-92 (*Gossypium hirsutum* L.) were plant materials. Zinc application treatments were seed, soil surface, foliar application and untreated control. A commercial preparation of chelated zinc (EDTA Zn-17 %) was used as zinc fertilizer. It was determined that zinc application methods did not affect yield and yield components except plant height. While zinc application methods had no effect on lint quality traits except spinning consistency index (SCI), elongation and yellowness (+b), which are the best values, were taken from the soil surface and foliar application of zinc and control for spinning consistency index, and from the foliar application of zinc for yellowness. On the other hand, zinc application methods did not affect raw oil and protein ratio of cotton seeds, as well as the zinc content of cotton seeds and leaves. When the pH, organic matter, lime content and soil texture were taken into consideration, decreasing of pH value and lime content of soil and increasing of organic matter together with zinc fertilization in the experimental field were suggested.

Key words: Cotton, zinc (Zn) fertilizer, application methods, seed cotton yield, lint quality, seed quality.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an industrial crop which has an important place in the world agriculture and trade. A number of researches have been established on cotton that is valuable for many industries besides textile industry depending on the requirements of human being and rapid developments in the industry. In Turkey, cotton sowing area and seed cotton production is about 420.000 ha and 1.725.000 tonnes, respectively. With this, lint cotton production is 638.250 tonnes, seed cotton yield is 4.110 kg/ha and lint yield is 1.520 kg/ha. In Kahramanmaras, cotton sowing area is 7.048.4 ha, seed cotton production is 23.266 tonnes, lint cotton production is 8608 tonnes, seed cotton yield is 3.380 kg/ha and lint yield is 1.220 kg/ha (Anonymous, 2009).

Nutrient elements must be sufficient enough in the growing environment of the plant to obtain high quality and more yield. Both plant growth and yield are negatively affected by deficiency of nutrient elements and lint quality is decreased as well. The amount of plant nutrient elements taken by cotton plant from soil varies depending on many factors. The species of *Gossypium* takes more nutrients from the soil. Cotton plant grown under irrigation conditions takes more nutrient elements. Among micro nutrient elements, cotton plant utilizes calcium (Ca) mostly followed by nitrogen (N) and potassium (K). Besides these elements, cotton plant needs zinc (Zn) which is a micro nutrient element and it can be sensitive in case of deficiency (Kacar and Katkat, 2007). Zinc is an indispensable element for healthy life of humans, animals and plants. It has important functions in protein and carbohydrate metabolism of plants. Furthermore, zinc is an element which directly affect yield and quality because of its function such as its activity in biological membrane stability, enzyme activation ability and auxin synthesis (Marschner, 1997; Oktay et al.,

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1998). In 49% of the soils in Turkey, zinc level is lower than 0.5 mg /kg which is at critical level. Also, in a large part of the soils in Turkey there are zinc deficiencies close to critical level. Linear relationship (Y = 0.16 + 0.362 X and R^2) between useful zinc quantity and organic matter content in the soils of Turkey were found positive and statistically significant (Eyupoglu et al., 1998a). Usefulness of zinc like the other micro elements is affected by organic matter quantity and properties of the soil. Organic matter affects usefulness of zinc by forming complex or making Zn adsorbtion with humic and fulvic acid fractions. The effect of Zn-organic matter complexes on usefulness of zinc depends directly on dissolution of this complex compounds (Tisdale et al., 1985).

Although, zinc as nutrient element is extremely important for plant production, its uptake from the soils can be easily blocked depending on many factors and its quantity decreased continiously. A study carried out in Turkey with 1511 soil samples showed that pH value was more than 7.0 in 91.8% of the soils. This finding has shown close relationship between zinc deficiency and soil pH value in Turkey soil (Ulgen and Yurtsever, 1984; Eyupoglu et al., 1998b). Because of adsorbtion of zinc by carbonates in lime soils or formation of compounds which has low dissolution such as $ZnCO_3$ and $Zn(OH)_2$, Zn^{+2} is transformed into unuseful form in the soil (Viets, 1966; Navrot and Ravikovitch, 1969; Trehan and Sekhon, 1977). Sodium and salt content increases where ground water is higher. In these lands, keeping the soils under water usefulness of zinc can be increased up to a period (Aydın et al., 1998). When these matters are taken into consideration, it can be said that zinc fertilization is necessary in the soils of Turkey. Maize, bean, cotton, flax, various fruits and walnut are more sensitive plants to zinc deficiency. On the contrary, sorghum, alfalfa, cereals, meadow grass and vegetables are less sensitive plant (Saglam, 1999). Symptoms of zinc deficiency include smaller young leaves, chlorotic inter-vascular leaves, red spots occurrence in leaf blade. Internodes become shorter; plants become dwarf and appear like shrub, in advance rosette (Anonymous, 2007).

In this study, the effect of different zinc application methods on seed cotton yield, yield components, lint and seed quality was investigated under east Mediterranean region conditions (Kahramanmaras-Turkey).

MATERIALS AND METHODS

Materials

In this study, three cotton varieties Agdas-3 and Agdas-17 (*G. hirsutum* L.) brought from Azerbaijan and Maras-92 (*G. hirsutum* L.) developed in Kahramanmaras were used as the planting material. A commercial preparation of chelated zinc (EDTA Zn-17%) was used as zinc fertilizer in seed, soil and foliar application. Kahramanmaras is a province located in the east Mediterranean region of Turkey and it has typical Mediterranean climatic conditions comprises of hot and dry weather in summers and warm and rainy weather in winters. Some physical and chemical properties of soil samples taken from 0 to 30 cm depth in the experimental field are shown in Table 1.

Soil texture of the experimental field was clay-loam with very high lime content (32.18%). The soil was not salty but alkaline (pH 7.95) with lack of organic matter, phosphorus, iron, and zinc. However, the soil contained sufficient amount of potassium and copper with high manganese (Table 1).

Methods

The study was carried out in 2008 in the experimental field of Kahramanmaras Sutcu Imam University, Faculty of Agriculture. The split plot experimental design was used with three replications. Application methods of zinc fertilizer were in main plots; cotton varieties were in subplots. The seeds of cultivars were sown by experimental mechanical planter in four-row plots of 10 m length at a planting space of 70 cm on 21 May 2008. After emergence, when plants had 4 to 5 leaves, they were thinned to 20 cm in rows. During the growing season, plants were hoed and harrowed 3 times to protect growing cotton seedlings from weeds, to prevent evaporation of soil water, and to aid development and deepening of roots of seedlings. Plants were furrow irrigated 7 times during the growing season as needed by the plants. Nitrogen was applied as one-third at presowing period, one-third at 36 days after sowing at presquaring period (prior to first irrigation), one-third at 54 days after sowing at the beginnig of flowering (prior to second irrigation) by using a fertilizer spreader in inter-rows at a total of 20 kg/da. Phosphorus was applied at presowing period at a rate of 6 kg/da P_2O_5. Composed fertilizer (20:20:0) and 46% of urea were used at presowing and surface fertilization, respectively. In this study, there were three different methods of Zinc (Zn) application and control (untreated):

1. Seed application: The seeds of tested cotton cultivars were kept overnight (10 to 12 h) before sowing in the solution of 10 L prepared using a commercial preparat of chelated Zinc (EDTA Zn-17%) at the rate of 100 g/kg seeds.
2. Soil surface application: For each plots, 80 g of a commercial preparation of chelated zinc (EDTA Zn- 17%) was dissolved in 12 L of water and sprayed using atomizer to the surface of soil of one plot (28 m^2). Immediately after application, seeds of cultivars were sown.
3. Foliar application: Zinc fertilization was applied at three growing stages. At the first stage in which plants had 5 to 7 leaves in each plot, 80 g of commercial chelated Zinc (EDTA Zn- 17%) was dissolved in the water of 12 L and the whole solution was sprayed using atomizer to the whole plants in one plot (28 m^2) early in the morning. Second application was made at 50% of squaring stage. Third application was made after 10 days from second application.
4. Control (untreated): Zinc fertilizer was not applied to these plots. In foliar application and control, the seeds was not treated with water before sowing.

Before harvesting, 25 boll samples were taken at random from two rows in the middle of each plot when 50 to 70% of bolls opened (Efe, 2000). Plants were hand picked on 19, September and 08, October from two rows in the middle of each plot. Seed cotton yield, yield components, fiber quality traits, raw oil and protein ratio of cotton seed, zinc content in cotton seed and leaf were investigated. After ginning of the boll samples, fiber properties were determined by using HVI (high volume instruments) instrument. Raw oil ratio of cotton seed was determined by using the method of soxhlet extraction. Raw protein ratio of cottonseed was determined by using Kjeldahl method (AOAC, 1990). Zinc content in cotton seeds were determined by using microwawe and atomic absorbtion spectrophotometric method. Zinc content in cotton leaf was determined by using atomic absorbtion spectrophotometric method.

Table 1. Some physical and chemical properties of soil of the experimental field (Anonymous, 2008).

Analysis	Result	Reference	Explanation
pH	7.95	6.6-7.3	Alkaline
Lime (%)	32.18	5.0-10.0	Very high
Salt (%)	0.04	0.0-0.15	Too low
Organic matter (%)	0.49	2.0-3.0	Very low
Phosphorus (ppm)	4.82	7-20	Low
Potassium (ppm)	150	200-250	Sufficient
Saturation (%)	55	30-50	Clay-loam
Iron (ppm)	0.97	4.5<	Deficient
Copper (ppm)	1.21	0.2<	Sufficient
Manganese (ppm)	9.97	1<	High
Zinc (ppm)	0.44	1<	Deficient

Duncan'smultiplerange test: Meanvaluessharingthesameletterare not significantlydifferent (P > 0.05).

The data obtained were analysed according to split plot design with three replications by using the SPSS statistical package program (Efe et al., 2000) and the means were compared by using Duncan multiple comparison test at 0.05 significant level (Bek and Efe, 1995).

RESULTS AND DISCUSSION

Statistically, differences were determined among different application methods of zinc for plant height (P<0.05), spinning consistency index (SCI) (P<0.05), elongation (P<0.05) and yellowness (+b) (P<0.01). Differences were also determined for brightness and yellowness among varieties. For plant height (P<0.01), fiber uniformity (P<0.01) and short fiber index (P<0.05), treatment x variety interaction was statistically significant. Means of zinc application methods, cultivars and treatment x variety interactions for seed cotton yield and yield components and groupings are given in Table 2.

As seen in Table 2, it was determined that zinc application methods did not affect the yield and yield components except plant height. Means of plant height for zinc application methods varied between 76.9 cm (seed application) and 71.4 cm (foliar application). Means of sympodial branch numbers for zinc application methods varied between 9.6 (seed application) and 8.7 (foliar application). Means of boll number per plant for zinc application methods varied between 14.0 (seed application) and 12.5 (foliar application). Means of seed cotton yield for zinc application methods varied between 3149 kg ha^{-1} (foliar application) and 2901 kg ha^{-1} (seed application). Means of ginning outturn for zinc application methods ranged from 41.4% (foliar application) to 40.4% (seed application) (Table 2).

From Table 2, the longest plant height (80.5 cm) was obtained from cv Agdas-17 while zinc was applied to seeds and the cultivar Maras-92 untreated. The cv Agdas-17 untreated resulted in shortest plant height (65.7 cm). Sympodial branch numbers of tested varieties were 9.3 (cv. Agdas-3), 8.7 (cv. Agdas-17) and 9.5 (cv. Maras-92). Boll numbers per plant of tested varieties were 13.1 (cv. Agdas-3), 12.4 (cv. Agdas-17) and 14.8 (cv. Maras-92). Seed cotton weight per boll of tested varieties were 5.9 (cv. Agdas-3), 5.9 (cv. Agdas-17) and 6.0 (cv. Maras-92). Seed cotton yields of varieties were 2975 kg ha^{-1} (cv. Agdas-3), 3177 kg ha^{-1} (cv. Agdas-17) and 3075 kg ha^{-1} (cv. Maras-92). Ginnig outturn values of tested varieties were 40.2% (cv. Agdas-3), 41.2% (cv. Agdas-17) and 41.5% (cv. Maras-92).

For 100 seed weight and fiber quality traits, means of zinc application methods, cultivars and treatment x variety interactions and groupings are given in Table 3.

As seen in Tables 3 and 4, zinc application methods did not affect lint quality traits except spinning consistency index (SCI), elongation and yellowness (+b). Means of fiber length for zinc application methods varied between 29.3 mm (foliar application) and 28.8 mm (seed application). Means of fiber fineness for zinc application methods varied between 4.8 mic. (seed application) and 4.5 mic. (control application). Means of fiber strength for zinc application methods varied between 32.2 g tex^{-1} (soil surface and control application) and 30.7 g tex^{-1} (seed and foliar application). Means of spinning consistency index for zinc application methods ranged from 157.2 to 170.7. The best values were taken from soil surface and foliar application of zinc and control for spinning consistency index (Table 3). Means of elongation for zinc application methods varied between 5.6% (seed application) and 6.0% (foliar application) (Table 3).

Fiber length values of varieties were 28.9 mm (cv. Agdas-3), 29.0 mm (cv. Agdas-17) and 29.3 mm (cv. Maras-92). Fiber fineness values of varieties were 4.7 mic. (cv. Agdas-3), 4.8 mic. (cv. Agdas-17) and 4.5 mic. (cv. Maras-92). Fiber strength values of varieties were 32.1 g tex^{-1} (cv. Agdas-3), 31.7 g tex^{-1} (cv. Agdas-17) and 31.5 g tex^{-1} (cv. Maras-92). Spinning consistency index values of varieties were 165.2 (cv. Agdas-3), 163.0 (cv. Agdas-17) and 169.8 (cv. Maras-92). Elongation values

Table 2. Means of zinc application methods, cultivars and treatment x variety interactions for seed cotton yield and yield components and groupings.

Parameter	Plant height (cm)	Sympodial branch number	Boll number per plant	Seed cotton weight per boll (g)	Seed cotton yield (kg ha^{-1})	Ginning outturn (%)
Seed application (means)	76.9±1.614	9.6±0.387	14.0±1.191	5.9±0.104	2901±10.945	40.4±0.814
Agdas-3	73.5±2.598[a-d]	9.6±0.833	12.7±0.742	5.8±0.285	2930±14.107	38.3±0.889
Agdas-17	80.5±2.677[a]	9.9±0.371	12.1±0.874	6.0±0.203	2883±5.044	42.4±1.278
Maras-92	76.5±2.240[ab]	9.4±0.945	17.3±2.743	5.9±0.058	2890±25.106	40.5±2.661
Soil application (means)	73.8±1.709	9.1±0.535	13.4±0.735	5.9±0.157	3129±8.186	41.3±0.697
Agdas-3	75.0±4.632[a-c]	9.4±0.872	14.1±1.235	6.1±0.296	3053±18.550	41.2±1.577
Agdas-17	74.4±2.946[a-c]	8.8±1.332	12.9±1.841	6.0±0.219	3363±20.995	41.4±0.867
Maras-92	71.9±1.462[b-d]	9.0±0.902	13.3±1.091	5.5±0.208	2970±17.088	41.1±1.317
Foliar application (means)	71.4±1.576	8.7±0.402	12.5±0.870	6.0±0.112	3149±9.292	41.4±0.791
Agdas-3	69.5±0.593[b-d]	8.8±0.462	11.3±0.467	5.9±0.145	2877±5.207	41.1±2.239
Agdas-17	67.6±1.732[cd]	7.9±0.968	12.5±2.491	5.8±0.173	3273±18.003	40.6±0.491
Maras-92	77.0±1.301[ab]	9.3±0.533	13.8±1.026	6.2±0.231	3297±14.333	42.5±0.351
Control application (means)	73.0±2.611	9.4±0.418	13.7±1.255	6.0±0.114	3123±8.109	40.9±0.649
Agdas-3	72.9±1.179[a-d]	9.5±0.437	14.3±2.949	6.0±0.233	3040±14.364	40.3±0.569
Agdas-17	65.7±3.184[d]	8.5±0.546	12.2±1.848	5.9±0.219	3187±13.569	40.5±0.458
Maras-92	80.5±3.875[a]	10.2±0.917	14.7±2.228	6.1±0.186	3143±18.487	41.9±1.650
Means of Agdas-3	72.7±1.318	9.3±0.306	13.1±0.797	5.9±1.340	2975±8.175	40.2±0.705
Means of Agdas-17	72.1±2.111	8.7±0.438	12.4±0.797	5.9±1.094	3177±8.311	41.2±0.604
Means of Maras-92	76.5±1.396	9.5±0.383	14.8±0.944	6.0±1.364	3075±9.136	41.5±0.685

Duncan'smultiplerange test: Meanvaluessharingthesameletterare not significantlydifferent ($P > 0.05$).

of varieties were 5.7 (cv. Agdas-3), 5.9 (cv. Agdas-17) and 5.7 (cv. Maras-92).

For some lint quality traits means of zinc application methods, cultivars and treatment x variety interactions and groupings are given in Table 4.

As seen in Table 4, means of fiber uniformity for zinc application methods varied between 86.3% (foliar and control application) and 85.3% (seed application). Means of trash count for zinc application methods varied between 3.9 (seed application) and 6.0 (control application). Means of brightness for zinc application methods varied between 76.3 (seed application) and 77.5 (control application). For yellowness, the best value was taken from foliar application of zinc (8.4). Means of short fiber index for zinc application methods varied between 6.3% (foliar application) and 7.1% (seed application) (Table 4).

Fiber uniformity values of tested varieties were 85.9% (cv. Agdas-3), 85.7% (cv. Agdas-17) and

Table 3. Means of zinc application methods, cultivars and treatment x variety interactions for 100 seed weight and fiber quality traits and groupings.

Parameter	100 Seed weight (g)	Fiber length (mm)	Fiber fineness (micronaire)	Fiber strength (g tex^{-1})	Spinnig consistency index (SCI)	Elongation (%)
Seed application (means)	11.1±0.130	28.8±0.376	4.8±0.109	30.7±0.783	157.2±3.265^{b}	5.6±0.157
Agdas-3	11.2±0.167	28.7±0.829	5.2±0.061	31.7±2.341	160.7±4.90	5.5±0.328
Agdas-17	10.7±0.167	28.3±0.368	4.8±0.222	29.9±0.120	149.3±3.11	5.7±0.265
Maras-92	11.3±0.167	29.5±0.376	4.5±0.165	30.5±0.503	161.7±2.20	5.6±0.176
Soil application (means)	11.4±0.139	28.9±0.330	4.7±0.083	32.2±0.442	167.1±3.355^{a}	5.8±0.105
Agdas-3	12.0±0.289	29.0±0.761	4.8±0.211	33.3±1.358	169.0±4.82	5.8±0.536
Agdas-17	11.3±0.333	28.8±1.124	5.0±0.120	31.6±1.662	162.0±8.01	5.7±0.067
Maras-92	11.3±0.167	28.8±0.448	4.4±0.275	31.6±1.302	170.3±5.74	5.7±0.115
Foliar application (means)	11.4±0.111	29.3±0.186	4.6±0.076	30.7±0.231	169.1±3.209^{a}	6.0±0.120
Agdas-3	11.3±0.167	28.4±0.496	4.6±0.117	32.9±0.491	156.0±2.72	5.9±0.058
Agdas-17	11.2±0.167	29.9±0.508	4.7±0.179	32.9±0.491	174.3±3.69	6.2±0.203
Maras-92	11.7±0.167	29.7±0.598	4.6±0.015	31.6±1.457	177.0±4.53	5.8±0.208
Control application (means)	11.3±0.118	29.1±0.250	4.5±0.061	32.2±0.518	170.7±2.799^{a}	5.7±0.090
Agdas-3	12.0±0.289	29.4±0.607	4.4±0.012	32.5±0.590	175.3±1.72	5.5±0.000
Agdas-17	11.2±0.167	28.8±0.367	4.6±0.124	32.5±0.674	166.3±5.44	5.7±0.120
Maras-92	11.3±0.167	29.1±0.385	4.6±0.146	31.6±1.457	170.3±6.41	5.9±0.219
Means of Agdas-3	11.4±1.306	28.9±0.330	4.7±0.092	32.1±0.664	165.2±3.263	5.7±0.135
Means of Agdas-17	11.1±1.446	29.0±0.256	4.8±0.092	31.7±0.452	163.0±2.801	5.9±0.090
Means of Maras-92	11.4±1.000	29.3±0.290	4.5±0.059	31.5±0.598	169.8±2.982	5.7±0.112

Duncan'smultiplerange test: Meanvaluessharingthesameletterare not significantlydifferent (P > 0.05).

Table 4. Means of zinc application methods, cultivars and treatment x variety interactions for some fiber quality traits and groupings.

Parameter	Fiber uniformity (%)	Trash area (%)	Trash count	Brightness degree	Yellowness degree	Short fiber index (%)
Seed application (means)	85.3±0.358	0.1±0.010	3.9±0.860	76.3±0.583	9.0±0.164^{b}	7.1±0.248
Agdas-3	86.3±0.376^{ab}	0.1±0.023	5.3±1.856	75.0±0.551	8.7±0.145	6.8±0.578^{a-c}
Agdas-17	84.3±0.371^{b}	0.1±0.015	5.3±1.453	75.7±1.093	9.4±0.133	7.6±0.367^{c}
Maras-92	85.2±1.073^{ab}	0.3±0.003	1.0±0.000	78.2±1.099	8.8±0.300	6.8±0.260^{a-c}
Soil application (means)	86.1±0.422	0.1±0.011	4.3±1.653	77.0±0.678	8.9±0.186^{b}	6.4±0.247
Agdas-3	86.0±0.088^{ab}	0.1±0.037	4.0±2.082	76.5±0.493	8.6±0.153	6.3±0.273^{ab}
Agdas-17	86.0±0.133^{ab}	0.1±0.012	3.3±0.333	75.9±0.742	9.6±0.088	6.2±0.379^{ab}
Maras-92	86.4±0.751^{ab}	0.1±0.019	5.7±0.333	78.7±0.176	8.4±0.240	6.8±0.233^{a-c}
Foliar application (means)	86.3±0.251	0.1±0.012	5.6±0.861	77.3±0.434	8.4±0.069^{a}	6.3±0.201

Table 4. Continues.

Agdas-3	84.6±0.458^{ab}	0.1±0.058	6.7±3.180	77.3±0.470	8.5±0.353	6.8±0.529^{a-c}
Agdas-17	86.9±0.333^{ab}	0.1±0.028	7.7±6.173	75.6±2.425	8.4±0.296	6.1±0.484^{ab}
Maras-92	87.4±0.451^{a}	0.1±0.020	2.3±0.333	78.8±0.769	8.2±0.133	6.0±0.351^{ab}
Control application (means)	86.3±0.296	0.1±0.020	6.0±0.957	77.5±0.345	8.9±0.142^{b}	6.5±0.250
Agdas-3	86.8±0.208^{ab}	0.1±0.035	7.7±0.882	77.5±0.451	9.1±0.203	5.8±0.273^{a}
Agdas-17	85.5±0.441^{ab}	0.1±0.020	6.0±2.082	77.6±0.612	9.0±0.306	6.6±0.384^{a-c}
Maras-92	86.7±0.513^{ab}	0.1±0.020	4.3±1.764	77.4±0.921	8.6±0.145	7.0±0.296^{bc}
Means of Agdas-3	85.9±0.312	0.1±0.017	5.9±0.930	76.6±0.384^{b}	8.8±0.148^{b}	6.4±0.261
Means of Agdas-17	85.7±0.340	0.1±0.010	5.6±1.382	76.2±0.652^{b}	9.1±0.160^{b}	6.7±0.152
Means of Maras-92	86.4±0.272	0.1±0.008	3.3±0.795	78.3±0.480^{a}	8.5±0.113^{a}	6.7±0.282

Duncan'smultiplerange test: Meanvaluessharingthesameletterare not significantlydifferent ($P > 0.05$).

86.4% (cv. Maras-92). Trash count values of tested varieties were 5.9 (cv. Agdas-3), 5.6 (cv. Agdas-17) and 3.3 (cv. Maras-92). Brightness values of tested varieties varied between 76.2 and 78.3 and the brightest fibers were taken from cv Maras-92 (78.3). Yellowness values of tested varieties varied between 8.5 and 9.1 and among tested varieties, the least yellow (8.5) fibers were taken from cv. Maras-92. Short fiber index values of tested varieties were 6.4 (cv. Agdas-3), 6.7 (cv. Agdas-17) and 6.7 (cv. Maras-92) (Table 4).

The highest fiber uniformity index (87.4%) was obtained from cv Maras-92 for zinc fertilizer application to leaves. The lowest fiber uniformity index (84.3%) was obtained from cv Agdas-17 for zinc fertilizer application to seeds. The lowest short fiber index (5.8 %) was obtained from cv Agdas-3 untreated control. The highest short fiber index (7.6%) was obtained from cv Agdas-17 for zinc fertilizer application to seeds.

Means of zinc application methods, cultivars and treatment x variety interactions for raw oil and protein ratio in seeds and zinc content in seeds and leaves are given in Table 5.

It was determined that zinc application methods did not affect raw oil and protein ratios of cotton seeds, zinc content in cotton seeds and leaves (Table 5). Means of raw oil ratios in seeds for zinc application methods varied between 18.4% (control application) and 20.2% (foliar application). Means of raw protein ratios in seeds for zinc application methods varied between 20.6% (seed application) and 23% (soil surface application). Means of zinc content in seeds for zinc application methods varied between 21.4 mg kg^{-1} (seed application) and 23.1 mg kg^{-1} (control application). Means of zinc content in leaves for zinc application methods varied between 44.0 ppm (foliar application) and 52.3 ppm (seed application) (Table 5).

Raw oil ratios in seeds of the varieties were 19.0% (cv. Agdas-3), 19.3% (cv. Agdas-17) and 20% (cv. Maras-92) respectively (Table 5). Raw protein ratios in seeds of the varieties were 21.8% (cv. Agdas-3), 21.5% (cv. Agdas-17) and 22.1% (cv. Maras-92) respectively. Zinc content values in seeds of the varieties were 22.0 mg kg^{-1} (cv. Agdas-3), 19.7 mg kg^{-1} (cv. Agdas-17) and 25.0 mg kg^{-1} (cv. Maras-92). Zinc content values in leaves of the varieties were 44.9 ppm (cv. Agdas-3), 48.6 ppm (cv. Agdas-17) and 46.3 ppm (cv. Maras-92) respectively.

When physical and chemical properties of soil from the experiment field (Table 1) was assessed, it was determined that the soil contain insuffient zinc that led to Zn deficient symptoms in the crops grown. In Table 1, it is shown that the pH degree of the soil is 7.95. Eyupoglu et al. (1998b) reported that the most zinc deficiency occur in the soils in which pH degree is between 7 to 8 and that useful zinc content decreases as soil pH increases. In Table 1, it is shown that organic matter content is 0.49%. In most zinc deficient soils, the organic matter content is lower than 1% and it is possible that zinc deficiency in the experiment field vary depending on the organic matter content. Zinc deficiency is highest in clay-loam soil (Marschner, 1997). Therefore, zinc deficiency in the experimental field may have been influenced by the soil texture. In this study, lime content in the soil of experiment field was 32.18%. Also, one of the reasons zinc deficiency in the field is very high lime content. Eyupoglu et al. (1998b) noted that zinc deficiency can occur in the soils in which zinc content is lower than 0.5 ppm. In this study, zinc deficiency (0.44 ppm) was determined in the soil of experiment field.

Mert (2007) reported that effective root depth of cotton plant is 1 m depending on soil type, humidity, temperature and plant vigor. Based on this fact, it is possible that zinc may be present on seed coat and it could not be uptaken because it could not be transfered to effective root zone while plant germinate and grow.

As a result, it was determined that zinc application methods did not affect yield and yield components except plant height. While zinc application methods had no effect

Table 5. Means of zinc application methods, cultivars and treatment x variety interactions for raw oil and protein ratio in seed and zinc content in seed and leaf.

Parameter	Raw oil ratio in seed (%)	Raw protein ratio in seed (%)	Zinc content in seed (mg kg^{-1})	Zinc content in leaf (ppm)
Seed application (Means)	19.4±0.986	20.6±0.639	21.4±2.303	52.3±2.858
Agdas-3	18.3±2.011	19.3±1.264	18.0±0.615	50.5±6.724
Agdas-17	19.7±1.328	20.4±0.224	21.7±7.195	55.3±5.030
Maras-92	19,0±0.141	22.0±1.140	30.5±4.797	51.2±4.544
Soil application (means)	20.1±1.284	23.0±0.742	21.8±2.466	45.2±1.576
Agdas-3	19.3±0.860	22.4±0.953	21.3±2.319	41.8±2.737
Agdas-17	19.6±1.130	22.7±2.107	19.8±1.211	47.1±3.254
Maras-92	21,3±1.205	23.6±0.942	19.5±1.112	46.5±1.786
Foliar application (means)	20.2±0.810	22.2±0.867	22.6±3.033	44.0±2.805
Agdas-3	18.9±0.211	21.3±1.064	25.0±6.691	38.8±7.177
Agdas-17	22.8±1.099	23.3±2.054	22.0±3.611	47.7±2.778
Maras-92	18,9±0.240	22.1±1.637	21.9±5.123	45.4±3.661
Control application (means)	18.4±0.648	21.5±1.129	23.1±2.702	44.9±1.971
Agdas-3	19.1±1.060	24.0±1.160	23.8±1.574	48.5 ±3.316
Agdas-17	18.1±1.906	19.5±2.878	15.1±4.013	44.4±4.352
Maras-92	18.1±2.682	19.5±2.878	28.0±6.430	41.8±2.297
Means of Agdas-3	19.0±0.561	21.8±0.731	22.0±1.994	44.9±32.452
Means of Agdas-17	19.3±1.112	21.5±0.881	19.7±2.136	48.6±25.021
Means of Maras-92	20.0±0.702	22.1±0.809	25.0±2.626	46.3±20.659

Duncan'smultiplerange test: Meanvaluessharingthesameletterare not significantlydifferent (P > 0.05).

on lint quality traits except spinning consistency index (SCI), elongation and yellowness (+b), the best values were taken from soil surface and foliar application of zinc and control for spinning consistency index, from foliar application of zinc for yellowness. It was determined that zinc application methods did not affect raw oil and protein ratio of cotton seeds, zinc content in cotton seeds and leaves. Among varieties, the brightest (78.3) and the least yellow (8.5) fibers were taken from cv. Maras-92.

Inconclusion, when pH, organic matter and lime content and soil texture are taken into consideration, it can be suggested decreasing of pH value and lime content of soil and increasing of organic matter together with zinc fertilization in the experimental field. Because there was iron deficiency in the experimental field it can be necessary iron fertilization besides of zinc. Moreover, zin cfertilization of cotton with increased zinc and iron doses should also be tried fo rbetter results in further studies.

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