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Effects of Zinc Application on Yield and Some Yield Components in Peanut *(Arachis hypogaea)* in the Easthern Mediterranean Region

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ABSTRACT

The effect of soil and foliar Zn fertilization on two varieties of peanut's (*Arachis hypogaea*) yield and some yield components were examined in this study. Soil applications of Zn doses were 0, 10, 20 and 40 kg ha^{-1} whereas 0, 0.5, 1 and 1.5 kg ha^{-1} Zn were sprayed to leaves. Applications of dose amounts of Zn lead to remarkable increase in yield and 100-seed weight. The effect of Zn treatment found to be statistically important at P<0.01 levels. The highest yield was obtained at COM variety as 6580.0 kg ha^{-1} with 0.5 kg ha^{-1} Zn foliar application. The lowest yield was measured at NC-7 variety's control plot with 3660.0 kg ha^{-1} in 2007. Foliar application Zn was statistically determined to be important to NC-7 variety peanut's grain Zn concentration at P<0.05 levels in each year. The economic analyses revealed that 0.5 kg ha^{-1} foliar application of Zn provided maximum profit with 10271.2 USD Dollars ha^{-1}.

Keywords: Micronutrient; Peanut; Yield; Zinc application

Doğu Akdeniz Bölgesinde Yer Fıstığında Çinko Uygulamasının Verim ve Bazı Verim Unsurlarına Etkileri

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ÖZET

Bu çalışmada topraktan ve yapraktan Zn gübrelemesinin COM ve NC-7 yerfıstığı çeşidinde verim ve bazı verim unsurlarına etkisi araştırılmıştır. Topraktan 0, 10, 20 ve 40 kg ha^{-1}; yapraktan 0, 0.5, 1 ve 1.5 kg ha^{-1} dozları uygulanmıştır. Zn uygulama dozları verimde ve 100 dane ağırlığında önemli miktarda artışlara neden olmuştur. Zn uygulamasının verim ve 100 dane ağırlığına etkisi istatistiksel olarak P<0.01 düzeyinde önemli bulunmuştur. En yüksek verim 6580 kg ha^{-1} ile 0.5 kg ha^{-1} yapraktan Zn uygulaması yapılan COM çeşitinde elde edilmiştir. En düşük verim 3660 kg ha^{-1} ile NC-7 çeşidinin control parselinde (0 doz) ölçülmüştür. Yapraktan uygulamanın NC-7 çeşidinde tanenin Zn içeriğine etkisi istatiksel olarak P≤0.05 düzeyinde önemli bulunmuştur. Ekonomik analizlerde 10271.2 US Dolar ha^{-1} maksimum gelir sağlayan yapraktan 0.5 kg ha^{-1} Zn dozu önerilmiştir.

Anahtar Kelimeler: Mikroelement; Yerfıstığı; Verim; Zn uygulaması

1. Inroduction

Zinc deficiency is responsible for many severe health problems. Among them are impairments of physical growth, immune system and learning ability, combined with increased risk of infections (Hotz & Brown 2004; Gibson et al 2008; Cakmak 2009; Cakmak et al 2010). 80% of peanut production of Turkey comes from the Cukurova region and Fe, Zn and other micronutrient deficiency is very common soil nutritional problem. However, Zn deficiency is one of the widespread nutritional disorders in crop production (Dağhan et al 2013). A number of factors affect the probability of a particular crop developing zinc deficiency such as very high lime content, low organic matter content, alkaline pH, very high Zn adsorption capacity of the calcareous soils etc. (Çakmak et al 1998; Srinivasara et al 2008). Also in soils with low Zn, the uptake of Zn is negatively affected by N, P, K, Ca, Mg, Na, Fe, Cu and Mn (Cakmak et al 1998; Farshid 2011; Dağhan et al 2013; Surucu et al 2013). Moreover, solubility of Zn is more influential than its amount for the occurrence of Zn deficiency in crops (Cakmak 2009; Rayo & Lucena 2009). Thus, zinc deficiency has common occurrence for the soils of the world and Turkey (Surucu et al 2013). More than half of the Turkish soils have less than 0.5 mg kg^{-1} zinc which is inadequate for plant growth (Cakmak et al 1998; Erdal et al 2000; Cakmak 2008).

Some researchers claimed that zinc fertilization of alfalfa increased herbage, hay, dry matter, crude protein yields and zinc concentration (Ceylan et al 2009). Peanut is widely produced in Cukurova Region of Southeastern Turkey, and micronutrients' deficiency symptoms are common due to high pH, lime and low organic matter content of the soils (Irmak et al 2008). Thus, this study aims to determine the effect of various amounts and types of Zn application on peanut's yield production along with fat and protein content in high pH and calcareous soils Cukurova Region of Turkey.

2. Material and Methods

The experiment was carried out using COM and NC-7 peanut varieties in Adana, Turkey. The Mediterranean climate with an average rainfall of 600 mm is dominating in the study area. Soils have "thermic" temperature with "xeric" moisture (Soil Survey Staff 2006). Wheat, corn, cotton, soybean, peanut, sunflower and rapeseed are commonly cultivated crops in the region. Soil sample was taken from 0-30 cm depth of each experimental plot for the analisis of routine properties. Soils were air dried and passed through 2 mm sieve. The DTPA (diethylene triamine pentaacetic acid)-extractable Zn of soil (Lindsay & Norvell 1978) and Zn concentrations of leaves and nut samples were analized by by using Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES, Perkin-Elmer) (Kacar & Inal 2008). Oil contents of nuts were analyzed according to Soxhelet method (James 1995). Protein contents of grain were analyzedsemi-micro Kjeldahl method (AOAC 2000).

In 2006 and 2007, dose experiments were established in split-split plot arrangement in completely randomized block design with three replications. In the experiment, the main plots were varieties, sub plots were applications and sub-sub plots were doses. The Zn fertilizer treatments were 0, 10, 20 and 40 kg Zn ha^{-1} as $ZnSO_4$ on soil before plowing. In the foliar Zn application rates were 0, 0.5, 1 and 1.5 kg Zn ha^{-1}. Respective amounts of $ZnSO_4$ were dissolved in 15 L de-ionised water and sprayed three times in twenty days interval in equal portions after flowering started. The soil and plant analysis data were subjected to two-way ANOVA by SPSS 13.0 statistical package programme.The mean separation was made by Duncan's test at $P \leq 0.05$.

Partial Budgeting and Marginal Profitability Ratio (PB and MPR) methods were used to determine the most economic application rate under current market conditions (Perin et al 1976; CIMMYT 1988). Partial budgeting process includes the average yield, gross production rate (GPR), fertilizer and fertilization costs, total variable input costs (TVIC) and net income (NI) parameters.

Marginal Profitability Analysis of applications was conducted following the partial budgeting process. Marginal Profitability Ratio indicates the extra income which will be taken in return for the invested 100 $ input towards increasing the yield (CIMMYT 1988).

The economical analyses were performed with the following equations:

GPR= Average Yield (kg ha^{-1}) x Product Price (kg \$$^{-1}$)

TVIC= Fertilizer Cost (kg ha^{-1}) + Fertilizing labor (\$ ha^{-1})

NI= GSUD-TDGM

MPR= (Extra Net Income / Extra Total Variable Input Cost) x100

3. Results

3.1. The effect of zinc application on yield and 100-seed weight

The results of yields of experiment plots were presented in Table 1. The yield of NC–7 variety was 3781 kg ha^{-1} for control treatment (0 kg Zn ha^{-1}) and increased to 5406 kg ha^{-1} upon 10 kg Zn ha^{-1} application in 2006. Similar results were obtained for COM variety which the yield increased from 3876 kg ha^{-1} (control plot) to 4734 kg ha^{-1} with 10 kg ha^{-1} soil application of Zn. Moreover, all soil applied zinc significantly increased yield for both varieties (Table 1).

Foliar application of Zn was also effective on increasing yield. The yield was 3814 kg ha^{-1} in NC-7 variety without foliar application of Zn and increased to 4891 kg ha^{-1} with application of 0.5 kg ha^{-1} foliar-Zn and increased to 4953 kg ha^{-1} with 1 kg ha^{-1} foliar-Zn application in 2006. However, the yield of control plots for COM variety was higher than other three foliar Zn treatments and this is most probably due to the low sensitivity of COM variety to foliar applied Zn. This unexpected behaviour may be attributed to higher soil Zn concentration of the control plots (Table 4). However, differences in tolerance of species and varieties of some species to Zn were reported elsewhere (Cakmak et al 1998). Another suggestion to higher yield for control plot of COM variety may be due to the relatively high soil Zn content of the experimental plots. Similar results were obtained by soil and foliar Zn applications in 2007. Soil applied Zn, at the 10 kg ha^{-1} treatment, increased NC-7's yield from 3840 kg ha^{-1} (control) to 4840 kg ha^{-1}. Other Zn doses which 20 kg ha^{-1} and

Table 1- Effect of zinc application on crop yild

Çizelge 1- Çinko uygulaması verime etkisi

Mode of application	*Doses kg ha^{-1}*	*Crop yield* kg ha^{-1}*							
		NC-7 variety				*COM variety*			
		2006	*2007*	*Average*		*2006*	*2007*	*Average*	
Soil	0	3781	3840	1891	cd	3876	4340	4108	cd
	10	5406	4840	2708	ab	4734	5420	5077	ab
	20	4751	5440	2385	ab	4303	5890	5096	ab
	40	3912	5050	1976	bc	5685	5790	5737	ab
Foliar	0	3814	3660	1907	d	4738	5220	4979	ab
	0.5	4890	5360	2445	ab	4188	6580	5384	a
	1	4953	5340	2477	ab	4632	5890	5261	a
	1.5	4799	5330	4799	ab	4657	5580	5118	ab
CV		13% Significant* (P < 0.01)							

40 kg ha^{-1} also resulted in further increases to 5440 and 5050 kg ha^{-1} for NC-7, respectively. 10 kg Zn ha^{-1} treatments increased the nut yield from 4340 kg ha^{-1} to 5420 kg ha^{-1} for COM variety. The obtained nut yield for 20 and 40 kg Zn ha^{-1} treatments were comparatively higher than the control treatment. 0.5 kg Zn ha^{-1} foliar treatment in 2007 for NC-7 resulted in 1700 kg ha^{-1} absolute yield increase comparing the control treatment. The gross yield obtained for 1 and 1.5 kg ha^{-1} foliar Zn applications were 5340 and 5330 kg ha^{-1}, respectively. The foliar application to COM variety somehow resulted in better yield performance for all of the treatments in the second year.

The varying Zn application methods either to soil or to leaves in 2006 increased 100-seed weight for both varieties (Table 2). This increase was detrimental for 10 kg Zn ha^{-1} treatment in NC-7 variety. However, the COM variety responded better to increasing Zn application rates for this trait such as 2.0, and 7.5 g absolute increase. The increasing foliar Zn treatments resulted in better performance in 100 seed weight for NC-7 variety. Ther were significant improvements in size of nuts upon foliar application of Zn. The recorded values were 105.0, 116.5, 119.9 and 118.6 g per 100 seeds for control, 0.5, 1.0, and 2.0 kg ha^{-1} treatments, respectively. Despite similar responses were obtained for COM variety it was not as detrimental as NC-7 variety. Fertilization of peanut by either way resulted in increases in the 100 seed weight in 2007. The most concrete performance was obtained for 10 kg Zn ha^{-1} treatment (128.0 g) whereas COM variety similarly responded to all Zn rates of soil treatments (134.0-135 g per 100 seeds). The obtained range of 100 seed weight for NC-7 upon spraying Zn was 117.0 and 125.0 g. Despite COM variety showed similar trend to spraying, the seed size of this variety was comperatively larger with a 100 seed weight range of 133.0-141 g.

3.2. Effect of zinc application on oil and protein contents of grain

Oil and protein contents of grain samples were presented in Table 3.The oil content ranges for Soil Zn treatments in 2006 were 41.3-45.7% and 44.4-45.4% for NC-7 and COM varities, respectively. The oil contents in the subsequent year were significantly increased to ranges 46.6-48.1% and 46.2-48.0% for the respective varieties. Spraying Zn increased the oil contents of seeds for both varieties (45.4-47.3% for NC-7 and 45.6-48.7% for COM) but these increases were not significant. It is shown that Zn applications have not affected oil contents of peanut grain in both years. Either the soil applications or spraying of Zn did not differ the protein content of seeds

Table 2- Effect of zinc applicatio on 100-seed weight

Çizelge 2- Çinko uygulamasının 100 tane ağırlığına etkisi

Mode of application	*Doses kg ha^{-1}*	*100-seed weight * g*							
		NC-7 variety				*COM variety*			
		2006	*2007*	*Average*		*2006*	*2007*	*Average*	
Soil	0	114.8	123.0	118.9	b	114.7	129.0	121.8	a
	10	119.5	128.0	123.8	a	116.7	135.0	125.8	a
	20	115.2	130.0	122.6	a	122.2	134.0	128.1	a
	40	117.7	124.0	120.9	a	122.2	136.0	129.1	a
Foliar	0	105.0	117.0	111.0	b	115.5	133.0	124.2	a
	0.5	116.5	125.0	120.8	a	121.3	141.0	131.2	a
	1	119.9	124.0	121.9	a	119.4	142.0	130.7	a
	1.5	118.6	125.0	121.8	a	121.0	135.0	128.0	a
CV		5% Significant* (P<0.01)							

in 2006, but there was relatively higher deviation in protein content of NC-7 variety upon spraying (Table 3). In the second year of the experiment, the obtained protein contents were comperatively lower by 4.6-7.3% for NC-7 and 3.5-6.7% for COM. Despite positive relation between Zn treatments and protein contents of both varieties, Zn application did not affect protein content of seeds (Table 3). Some researchers reported that Zn application had a significant (P<0.05) effect on crude protein yield of alfalfa (Ceylan et al 2009).

3.3. Effect of zinc fertilization on zinc content of grain and leaf

The applicaition method, rates and year had significant effects on leaf and seed Zn concentrations (Table 4). Soil applied Zn was effective on both NC-7 variety's grain and leaf Zn concentration in 2006. The control plot's Zn concentration of grain was 37.0 mg kg^{-1} and raised to 55.0 mg kg^{-1} with increasing third doses which was 20 kg ha^{-1}. Similar to soil application, the foliar applied Zn enhanced grain and leaf Zn concentration of NC-7 variety which was 12.0 mg kg^{-1} at control plot and increased to 21.0 mg kg^{-1} at

Table 3- Effects of zinc application on oil and protein contents of peanut grain

Çizelge 3- Çinko uygulamasının yerfistığı tohumlarının yağ ve protein içeriğine etkisi

Mode of application	*Dose kg ha^{-1}*	*Oil content of grain %*				*Protein content of grain %*			
		NC-7 variety		*COM variety*		*NC-7 variety*		*COM variety*	
		2006	*2007*	*2006*	*2007*	*2006*	*2007*	*2006*	*2007*
Soil	0	44.3	48.1	45.4	46.2	33.2	27.3	30.2	24.9
	10	44.7	47.8	46.0	47.9	33.8	27.5	29.7	24.2
	20	41.3	46.8	44.4	47.4	33.8	27.7	29.0	25.5
	40	45.7	46.6	45.9	48.0	33.2	26.7	29.4	24.0
Foliar	0	44.9	46.4	46.6	48.7	31.8	25.9	29.5	23.9
	0.5	45.4	45.4	45.5	48.4	31.7	27.1	29.7	23.9
	1	45.3	46.8	46.5	48.3	33.2	27.4	29.8	23.5
	1.5	44.4	47.3	47.2	45.6	34.0	26.7	29.2	22.5
CV		4% ns				7% ns			

ns, not-significant

Table 4- Effects of zinc application on Zn concentrations of soil, leaf and grain samples

Çizelge 4- Çinko uygulaması toprak, yaprak ve tane Zn içeriğine etkisi

Dose kg ha^{-1}	*Zn concentration of soil mg kg^{-1}*				*Zn concentration of leaf mg kg^{-1}*				*Zn concentration of grain mg kg^{-1}*			
	NC-7 variety		*COM variety*		*NC-7 variety*		*COM variety*		*NC-7 variety*		*COM variety*	
	2006	*2007*	*2006*	*2007*	*2006*	*2007*	*2006*	*2007*	*2006*	*2007*	*2006*	*2007*
0	0.24	1.01	0.20	0.24	14.0	7.0	24.0	6.0	37.0	74.1	34.0	80.4
10	0.20	0.90	0.18	0.35	10.0	12.0	24.0	5.0	39.0	77.9	39.0	64.7
20	0.20	0.96	0.18	0.75	15.0	6.0	17.0	6.0	55.0	72.2	42.0	126.2
40	0.24	0.29	0.20	0.90	17.0	6.0	22.0	4.0	51.0	51.9	40.0	55.5
0	0.36	0.20	0.36	0.25	12.0	7.0	25.0	11.0	33.0	61.9	38.0	69.3
0.5	0.80	0.53	0.18	0.26	21.0	9.0	28.0	8.0	42.0	97.4	40.0	65.7
1	0.20	0.34	0.18	0.29	25.0	12.0	27.0	12.0	43.0	73.0	40.0	76.1
1.5	0.24	0.51	0.20	0.38	10.0	16.0	24.0	13.0	30.0	75.0	44.0	72.6
					*		ns		*		ns	

*, P < 0.05; ns, not-significant

second dose which 0.5 kg ha^{-1} foliar Zn application in 2006. The Zn concentration of grain resembling to leaf Zn concentration, the control plot's 33.0 mg kg^{-1} Zn increased to 42.0 mg kg^{-1} with foliar 0.5 kg ha^{-1} Zn application. Foliar application Zn was statistically determined to be important to peanut's grain Zn concentration at 0.05 levels. In 2007, soil applied Zn increased control plot's 74.1 mg kg^{-1} value to 77.9 mg kg^{-1} at the second doses, 10 kg ha^{-1} application. The leaves Zn concentration is also increased from 7.0 mg kg^{-1} (control plot) to 12 mg kg^{-1} at 10 kg ha^{-1} Zn treatment in the same year. The foliar application also increased NC-7's leaves Zn concentration of control plot from 7.0 mg kg^{-1} to 16.0 mg kg^{-1} at fourth application which was 1.5 kg ha^{-1} in 2007. NC-7 variety's grain Zn concentration rose from 61.9 mg kg^{-1} of control plot amount to 97.4 mg kg^{-1} in 0.5 kg ha^{-1} foliar application (Table 4).

3.4. Economic analyses of zinc rates and fertilization methods

The effects of different Zn treatments on the marginal profit ratio (MPR) is provided in Tables 5 and 6. The maximum profit was determined at 0.5 kg ha^{-1} foliar Zn application with 10271.2 \$ ha^{-1}. Based on MPR's in Table 5 and 6, Zn application doses of 20 and 40 kg ha^{-1} to soil and 1 and 1.5 kg ha^{-1} foliar spraying resulted in higher input expenses with lower income which gave negative MPR value. However, 10 kg ha^{-1} soil and 0.5 kg ha^{-1} foliar treatments revealed positive MPR values; the latter treatment has the maximum MPR with 1969.18% (Table 5 and 6).

Table 5- Economic analysis, partial budgeting and marginal profitability ratio of zinc dozes

Çizelge 5- Çinko dozlarının ekonomik analiz, kısmi bütçeleme ve marjinal karlılık oranına etkisi

Mode of application	*Dose kg ha^{-1}*	*Crop yield kg ha^{-1}*	*Gross production rate (GSUD (\$ ha^{-1})*	*Variable input costs (\$ ha^{-1})*	*Fertilizer and fertilization costs (\$ ha^{-1})*	*Total variable input costs (TDM) (\$ ha^{-1})*	*Net income (NG) (\$ ha^{-1})*
Soil	0	3958.60	7798.40	00.00	00.00	00.00	7798.40
	10	5097.70	10042.50	216.00	50.00	266.00	9884.50
	20	5095.40	10037.90	432.00	50.00	482.00	9555.90
	40	4825.30	9505.80	648.00	50.00	698.00	8807.80
Foliar	0	4359.70	8588.60	00.00	00.00	00.00	8588.60
	0.5	5257.20	10356.70	05.40	80.00	85.40	10271.20*
	1	5203.90	10251.70	10.90	80.00	90.90	10160.80
	1.5	5094.20	10035.60	16.30	80.00	96.30	9939.20

*, the most profitable peanut yield

Table 6- Economic analysis and marginal profitability ratio of zinc applications

Çizelge 6- Çinko uygulamalarının ekonomik analizi ve marjinal karlılık oranı

Mode of application	*Dose kg ha^{-1}*	*Total variable input costs (\$ ha^{-1})*	*Net income (NG) (\$ ha^{-1})*	*Marginal profitability ratio*
Soil	0	00.00	7798.40	
	10	266.00	9884.50	1320.27
	20	482.00	9555.90	-104.19
	40	698.00	8807.80	-346.34
Foliar	0	00.00	8588.60	
	0.5	85.40	10271.20	1969.18*
	1	90.90	10160.80	-2018.87
	1.5	96.30	9939.20	-4084.31

*, the most profitable peanut yield

4. Discussion

Majority of the experimental soils have an inadequate Zn concentration for crop production. The Zn concentration of soils collected in 2006 varied from 0.18 mg kg^{-1} to 0.80 mg kg^{-1}. Except the experimental plot of NC-7 variety which Zn was applied 0.5 kg ha^{-1} via foliar fertilization, majority of soils' Zn concentration were below the critical level of 0.5 mg kg^{-1}. The soil Zn level was 0.80 mg kg^{-1} at 0.5 mg kg^{-1} foliar fertilizer treated NC-7 variety's plot whereas at COM variety experiment the Zn concentration was 0.18 mg kg^{-1} both in soil and foliar fertilizer applications. The Zn concentration ranged from 0.20 mg kg^{-1} to 1.01 mg kg^{-1} in 2007 soil samples and most of the plot's soil Zn level was below the critical deficiency threshold value of 0.5 mg kg^{-1} (Table 4). The researches undertaken in agricultural soils of Turkey revealed that more than half of the Turkish soils have Zn deficiency. Zn deficiency is more common in soils with high phosphorous concentration or excessively fertilized with phosphorus (Cakmak et al 2010). Irmak et al (2008) reported severe Zn deficiency in the soils of Cukurova region. The field experiment revealed that both soil and foliar applications of Zn significantly increased yield and 100-seed weight of peanut. The averages of two yearly data for both soil and foliar Zn treatments revealed statistically significant increases in nut size/yield at P= 0.01 (Table 1 and 2). The positive relations between soil-Zn and yield were reported by several researchers in different crops (Cakmak et al 1998; Kalayci et al 1999; Togay et al 2005; Dağhan et al 2013). Some researchers claimed that Zn fertilizers were also highly effective in increasing grain yield of wheat and alfalfa (Erdal et al 2003; Ceylan et al 2009; Cakmak 2010).

The increasing application of Zn both to soil and leaves found to be statistically significant at P<0.01 for NC-7 variety. Despite there was a positive relation between Zn application rates and 100-seed weight for COM variety, the relation was not statistically significant enough (Table 2). Several authors reported increase in yield and 100-seed weight of crops upon Zn fertilization. When Zn and phytin acid content were considered co-application of Zn to soil and leaves was suggested (Cakmak 2010). Some researchers studied the effect of various Zn fertilizers on some agronomical properties and corncob production of sweet corn (*Zea mays saccharatasturt.*). The highest corncob yield was achieved at 2.5 g L^{-1} (Borrechel) foliar treatment with 8927 kg ha^{-1} (Büyükerdem & Akman 2008). Togay et al (2005) investigated the response of yield of various wheat species and lines to Zn application in Van (highland with continental climate), and determined significant effects on plant height, seed number per spike, grain Zn concentration, 1000-seed weight, and grain yield.

Zn concentrations in Zn treated plots and their respective grain Zn concentrations gave statistically significant relations at P<0.05 (Table 4). Several researchers determined significant Zn-induced yield (seed/nut) increases in plants (Erdal et al 2000; Cakmak 2009; Farshid 2011). Some researchers reported that cereal crops are inherently very low in grain Zn and Fe concentrations (Cakmak et al 2010). However, soil and foliar application of Zn both in 2006 and 2007 were statistically insignificant for COM variety's grain and leaf Zn concentration which may be related to low response of COM variety to Zn fertilization or heterogeneity of the experimental field in two successive years. Studies undertaken in Southeastern Anatolia (semi-arid continental climate) and Central Anatolia (arid continental) on the effect of Zn on phytinacid (PA), Zn and P concentrations in wheat revealed the significance of Zn fertilization. Thus, the regulation of P concentration and PA/Zn ratioin P deficient calcareous soils results in inreases in the biological availablity of Zn (Cakmak et al 1998; Erdal et al 2000; Cakmak 2009). In this regard we suggest 0.5 kg ha^{-1} foliar Zn application to Easthern Mediterranean Region's farmers for maximizing the profit (Table 5 and 6) in peanut cultivation.

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