THE EFFECT OF PHOSPHORUS AND ZINC ON YIELD AND ON SOME AGRONOMIC CHARACTERISTICS OF COTTON (*Gossypium hirsutum* L.)

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Abstract. This study was conducted to determine the effect of Phosphorus (P) i.e. (P_0= Control, P_{40}= 40, P_{80}= 80, and P_{120}= 120 kg ha^{-1}) and Zinc (Zn) i.e. (Zn_0= Control, Zn_{05}= 5, Zn_{10}= 10, and Zn_{15}= 15 kg ha^{-1}) on yield and on some agronomic characteristics of cotton (*Gossypium hirsutum* L.) Adiyaman, Turkey. The field experiments were arranged in a randomized complete block with a split plot design with three replications in years of 2011 and 2012. P and Zn treatments were applied in main and sub-plots, respectively. Cotton cultivar of Stoneville-453 was used in the experiment. Based on the results, phosphorus and zinc applications increased the seed cotton yield. The highest plant height was obtained from the interaction of P_{80} x Zn_5 and the highest number of bolls was taken from the interaction of P_{80} x Zn_{10}. In terms of the number of monopodial branches, statistically significant differences were found in both years, but this significance was not stable over the years. It was concluded that the combined treatments of phosphorus and zinc did not have a significant effect on the boll weight, boll seed cotton weight and ginning outturn. The effect of fertilizers on the number of sympodial branches and 100 seed weight were significant in the first year but not significant in the second year.
Keywords: *sympodial branch, agronomic traits, ginning, interaction, replications*

Introduction and literature review

In addition to being the main source of natural fiber, cotton is a plant that has an important place in global agriculture and trade with its oil, meal, and other by-products obtained from its seed. Cottonseed pulp is also used in animal nutrition. Along with the developing textile industry, the importance of cotton production in the world economy is increasing gradually. Fertilizer is an important input in cotton production and it has become a necessity for farmers to use for a profitable production. An important component of profitable cotton production is an adequate and balanced fertilization. In the case of cotton and most plants various yields are obtained due to the various growing conditions in different regions. It is necessary to apply cultural measures such as fertilization, tillage, and diseases and pest control as well as sowing, seedbed preparation, and other managements for higher yielding.

Today, the most applied fertilizer of cotton plant is nitrogen, the second one, phosphorus (P) is also one of the essential elements for plant development. Zinc and Phosphorus are important plant nutrients affecting plant growth directly. Phosphorus increases boll development by affecting the flower formation and fertilization biology in cotton. Despite the continuous addition of phosphorus from the organic and inorganic sources to the heavily cultivated soils, the phosphorus level of the soil is insufficient for profitable crop production. P is an essential element for metabolic functions and vital structures in plants. It is especially vital in early root development, photosynthesis, cell division, energy transfer, early boll development and early maturity (Stewart, 1998).

Phosphorus deficiency leads to deterioration of plant membranes and decreases energy transfer in the plant (Oosterhuis et al., 2007). P deficiency is one of the most

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important factors limiting the yield in plant production, especially in calcareous alkaline soils. Particularly above pH 7, phosphorus in the soil is fixed by cations such as calcium in the soil to form insoluble salts (Zhou et al., 2001). The phosphorus, which turns into salt, becomes useless for the plants (Castro and Torrent, 1995).

Phosphorous fertilizers, unlike nitrogen fertilizers, are fixed very tightly in the soil. Plants rarely intake more than 20% of the applied phosphorus. However, this rate is as high as 60% in nitrogen. Phosphorous fertilizers turn out to be beneficial for plants faster in soils with a pH of 5.5-7. The plant cannot sufficiently utilize it, as it is fixed too tightly under these pH degrees. These fertilizers are more beneficial when supplied with lime to acidic soils. As the lime prevents phosphorus to be fixed by minerals like iron and aluminum (Aydemir, 1982).

Phosphorous fertilizers can affect significantly the increase of the number of flowers and bolls, the size of bolls, and early maturity rather than the vegetative growth of cotton. It is claimed that phosphorus helps blooming, bearing fruits, and increases the yield in cotton, and that phosphorus deficiency in the soil results in the reduction of plant height as well as seed cotton yield by 30% (Şenel, 1980).

Crop yield is limited by the low levels of micronutrient minerals such as zinc (Zn) especially in arid and semi-arid regions of calcareous soils (Cakmak et al., 1999). Zinc is the most preferred micronutrient element to cotton. That is important in regulating the chlorophyll content and assimilation rate of the cotton leaf (Weir et al., 1996). Zinc plays an important role in some enzyme systems and catalyzes the process of disintegration in the plant cell. Moreover, it is also vital in the structural change of carbohydrates, chlorophyll formation and growth-promoting substances. Zinc also prevents withering by promoting water intake (Price, 1970). It was reported that the critical limit of zinc in the field soil is 0.5 ppm (Linsday and Norwel, 1978), and application of zinc as $ZnSO_4$ increases seed cotton yield significantly comparing non-applied control plot and a 25 kg ha^{-1} $ZnSO_4$ application gives the highest yield (Sharma and Gupta, 1988), furthermore, NPK+Zn application significantly increases the seed cotton yield and the number of bolls (Prasad and Prasad, 1994). 44 and 75 kg ha^{-1} phosphorous fertilization with 40 ppm foliar zinc application 75 and 90 days after sowing resulted in an increase in the number of bolls, boll weight, 100 seed weight, and seed cotton yield in cotton plants (Sawan et al., 1997). In addition, Soomro et al. (2000) also reported that due to a 5 kg ha^{-1} zinc sulfate application the cotton increased the number of bolls, boll weight, seed index, and seed cotton yield compared to the control. Zinc treatment was reported to increase the cotton yield compared to the control (Sawan et al., 2001) and phosphorus and zinc applications increase100 seed weight, seed cotton yield, and fiber yield (Elwan et al., 2002). Nevertheless, it was also stated that zinc application increased plant height the same treatment in soil with high pH and phosphorus content did not affect the yield (Ören and Başal, 2006). Panayotova et al. (2017) observed that 0, 40, 80, 120, and 160 kg ha^{-1} P applications, increased the seed cotton yield from 5.02 to 11.71%, the number of bolls from 3.0 to 25.9%, and plant height significantly.

Foliar zinc application twice i.e. (0 and 58 g ha^{-1}) 70 and 85 days after sowing, and the foliar phosphorus application twice i.e. (control, 576, 1152, and 1728 g ha^{-1}) 80 and 95 days after sowing increased seed cotton yield, number of bolls, 100 seed weight, and fiber yield (Sawan et al., 2008). Zinc treatments of the 0, 5, 7.5, 10, and 12.5 kg ha^{-1} doses a 7.5 kg ha^{-1} was stated to be the most effective zinc dose, and this zinc ratio increased 100 seed weight and seed cotton yield (Ahmed et al., 2010).

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This study aimed to assess the effect of phosphorus and zinc applications on the yield and agronomic characteristic of cotton in South East Anatolia.

Materials and methods

Field trials were carried out in zinc deficient soils of Old Hosni Mansur (Eskihüsnümansur) village of Adiyaman in Turkey in 2011 and 2012 growing seasons. Stoneville 453 cotton cultivar was employed as plant material.

Field trials were set up at the same location in both years, but on the different parts of experimental field showing Zn deficiency. Some soil properties of the experimental area were given in *Table 1*.

Table 1. *Soil properties of the field*

Soil properties	2011	2012
Saturation (%)	55	57
$Ec_{25}10^3$ (mmhos/cm)	0.083	0.079
pH (1:2:5)	7.60	7.45
P_2O_5 (kg ha^{-1})	8	21
K_2O_5 (kg ha^{-1})	799	691
Organic matter (%)	1.4	2.03
Lime Sodium N (me/L)	23.9	24.1
Cu (mg/L)	2.48	2.43
Mn (mg/L)	3.18	3.08
Fe (mg/L)	7.05	6.94
Zn (mg/L)	0.27	0.25

Anonymous, 2012a

Adiyaman is located at the transitional zone between coastal and continental climate conditions. Adiyaman province is located at 37°45’ north latitude and 38°16’ east longitude with an altitude of 672 m. Field trials were located at 37°41’47’ north latitude 38°20’55’ east longitude with a 547 m altitude from sea level (*Figure 1*).

Figure 1. *The map of the experimental area*

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In the 2011 growing season, the average temperatures were between 10.2°C to 32.3°C and the maximum temperatures were between 20.2°C and 42.5°C, while in the 2012 cultivation season the average temperatures were between 10.4°C to 32.5°C and the maximum temperature was between 20.5°C and 43.7°C (*Table 2*).

Table 2. *The official record of Meteorology Directory, Adiyaman, Turkey.*

	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Annual
2011										
Av. Temp.	10.2	16.1	21.3	26.4	32.3	31.4	25.4	17.6	10.4	17.6
Max Temp.	21.4	27.9	33.0	37.2	42.5	41.3	36.0	31.2	20.2	42.5
Min Temp.	0.4	2.7	5.7	13.3	18.0	20.7	15.3	5.8	0.0	-3.8
Total Precip.	80.6	25.4	36.5	13.5	0.0	3.5	0.4	44.1	70.8	457.7
2012										
Av. Temp.	10.8	16.7	21.8	29.1	31.1	32.5	25.6	19.4	10.4	17.9
Max Temp.	21.7	27.2	37.1	40.2	41.0	43.7	38.3	32.4	20.5	43.7
Min Temp.	2.0	4.0	9.0	15.3	20.4	20.8	12.9	10.0	1.7	-6.3
Total Precip.	62.3	64.9	33.9	0.1	0.0	0.1	0.3	82.8	90.7	678.0
Average temperatures for 10 years period (2002-2012)										
Av. Temp.	9.8	14.7	20.2	26.3	30.6	30.1	25.4	15.8	11.8	16.7
Max Temp.	24.7	30	36	40	44	43.5	40	35	28.2	44
Min Temp.	-6	-2	6	10.6	16.7	16.3	10.2	2.2	-3.2	-14.6
Total Precip.	111.3	82.9	51.4	5.9	1.5	0.8	3.8	30.6	76.7	798.1

Anonymous, 2012b

In the field trials, phosphorus (Triple Super Phosphate), and zinc sulfate heptahydrate ($ZnSO_4.7H_2O$) (22%) were used as treatments. The experiments were carried out by split plot in randomized complete blocks with 3 replications. P doses i.e. (P_0= Control, P_{40}= 40, P_{80}= 80, and P_{120}= 120 kg ha^{-1}) formed main plots and Zn treatments i.e. (Zn_0= Control, Zn_{05}= 5, Zn_{10}= 10, and Zn_{15}= 15 kg ha^{-1}) formed sub-plots. Each plot had a length of 12 m and consisted of 6 rows. There were 2 m alleys between plots, and 3 m between blocks 70 cm inter rows and 15 cm intra row spacing were allowed. Sowing was practiced on 22nd April in 2011, and 27th April in 2012, by a pneumatic drill. In total, a 160 kg ha^{-1} pure nitrogen was applied. Half of the nitrogen was given during the sowing and the remaining half was given by the lister tool just before the first irrigation. All of the phosphorus was given during the sowing by drill and the Zinc sulfate heptahydrate ($ZnSO_4.7H_2O$) was manually given into neighboring rows located 5-6 cm apart and depth from cotton seeded rows.

Irrigation was practiced seven times in 2011 and 8 times in 2012 applying 840 mm and 960 mm for consecutive years, respectively. Furrow irrigation method was performed. Agronomic managements were carried out based on common practices employed in the region. No spraying was carried out against pests in either year.

Seed cotton harvests were done manually (handpicking) on 23th September 2011 and 17th September 2012, respectively. Seed cotton yield (kg $plot^{-1}$) was scored taking into account two rows in the middle of 10 meters in each plot (10 m x 1.4 m = 14 m^2) excluding the one-meter area from both ends of the plot. The ginning outturn (%) was determined by the ginning of 0.5 kg of seed cotton collected from each plot. Plant height (cm), number of monopodial branches (per $plant^{-1}$), number of sympodial branches (per $plant^{-1}$), and number of bolls (per $plant^{-1}$) were calculated by scoring in 10 randomly selected plants in each plot. Boll weight (g), boll seed cotton weight (g) and

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100 seed weight (g) were scored by employing 35 boll samples randomly selected from plots just before harvest (Worley et al., 1976).

The data obtained from the experiment was analyzed by using the MINITAB 18 (Minitab Inc., USA) statistical software and analysis of variance was performed according to the split plot test in randomized complete block design and the means were grouped by the Tukey HSD ($p \leq 0.05$) test.

Results and Discussion

In the analysis of variance (ANOVA) according to the combined years of the properties examined in the trial, statistical differences were found between years. Due to that the results of each year were analyzed separately.

F values obtained from the analysis of variance of the traits under study in the experiment were given in *Table 3*.

Table 3. *Statistical significance (F) of some traits in the ANOVA*

	Seed Cotton Yield		**Plant Height**		**Monopodial Branches**		**Sympodial Branches**		**Number of Bolls**	
	2011	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
P	**	**	**	ns	**	ns	**	ns	**	**
Zn	**	**	**	*	**	**	ns	ns	ns	*
PxZn	**	**	**	**	**	**	**	ns	*	**

	Boll Weight		**Boll Seed Cotton Weight**		**Ginning Outturn**		**100 Seed Weight**	
	2011	**2012**	**2011**	**2012**	**2011**	**2012**	**2011**	**2012**
P	ns	ns	ns	ns	ns	ns	*	ns
Zn	ns	ns	ns	ns	ns	ns	ns	ns
PxZn	ns	ns	ns	ns	ns	ns	*	ns

* ($p \leq 0.05$), ** ($p \leq 0.01$), ns: non-significant

Seed cotton yield (kg ha^{-1}), plant height (cm), number of monopodial branches (no. $plant^{-1}$), number of sympodial branches (no. $plant^{-1}$), number of bolls (no. $plant^{-1}$), boll weight (g), boll seed cotton weight (g), ginning outturn (%) and 100 seed weight (g) were given in *Tables 4, 5 and 6*.

Seed Cotton Yield (kg ha^{-1})

Table 4 showed that the lowest seed cotton yield in 2011 was obtained from the control plot of P_0 x Zn_0 with as 3401 kg ha^{-1} and the highest yield was provided by the P_{120} x Zn_{15} interaction with 4595 kg ha^{-1}, while the lowest seed cotton yield in 2012 was again obtained from the control plot, of P_0 x Zn_0, with 2993 kg ha^{-1} and the highest yield was provided by the P_8xZn_1 interaction with 4189 kg ha^{-1}.

The lowest yield provided by the control plots in both years showed that phosphorus and zinc had some positive effects on yield. However, the highest yield varied in both years, and this fluctuation was based on various climatic and soil factors.

Sawan et al. (2006) found that phosphorus application at three concentrations (i.e. 600, 1200, and 1800 ppm P) significantly increased the seed cotton yield compared to control (9.49% -17.12%). Meanwhile, Singh et al. (2013) indicated that phosphate deficiency decreased plant growth and photosynthesis, thereby reduced biomass

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accumulation and yield. Russell (2001) claimed that phosphorus, as part of the cell nucleus, was important for cell division and the development of meristematic tissue, and therefore had a stimulating effect to increase the number of bolls and flowers per plant.

Table 4. *Means and the groups of seed cotton yield (kg ha^{-1}), plant height (cm) and monopodial branches (per plant)*

P X Zn Interactions		Seed Cotton Yield (kg ha^{-1})		Plant Height (cm)		Monopodial Branches (per plant)	
		2011	**2012**	**2011**	**2012**	**2011**	**2012**
P_o	Zn_0	3401 e*	2993 h*	74.4 f*	73.8 a*	0.8 de*	0.5 a*
	Zn_5	3787 cde	3188 fgh	76.2 cdef	68.2 bcd	1.0 bcd	0.1 e
	Zn_{10}	3461 e	3340 ef	75.6 def	67.8 bcd	1.3 ab	0.3 bcd
	Zn_{15}	3434 e	3127 fgh	74.6 ef	68.2 bcd	1.3 ab	0.2 cde
P_{40}	Zn_0	4136 abcd	3213 fgh	77.4 b-f	72.7 ab	0.8 de	0.2 cde
	Zn_5	4158 abcd	3068 gh	76.9 b-f	70.2 abc	0.9 cde	0.3 bcd
	Zn_{10}	3706 de	3006 h	75.4 def	65.6 cd	1.2 ab	0.2 cde
	Zn_{15}	3888 bcde	3575 cd	78.6 abcd	65.5 cd	0.8 de	0.3 bc
P_{80}	Zn_0	4046 bcd	3259 efg	79.9 abc	64.2 d	1.1 abc	0.2 cde
	Zn_5	3978 bcd	3748bc	82.4 a	73.3 a	1.0 bcd	0.3 bc
	Zn_{10}	4182 abcd	4189 a	78.9 abcd	69.8 abc	1.4 a	0.3 bcd
	Zn_{15}	4340 ab	3904 b	78.0 b-f	70.1 abc	0.7 e	0.3 bc
P_{120}	Zn_0	4246 abc	3452 de	79.1 abcd	71.2 ab	1.1 abc	0.4 ab
	Zn_5	3736 cde	3671 cd	78.5 a-e	67.8 bcd	1.4 a	0.3 bcd
	Zn_{10}	3761 cde	3659 cd	75.5 def	70.3 abc	1.0 bcd	0.3 bc
	Zn_{15}	4595 a	3329 ef	80.3 ab	70.9 ab	1.3 ab	0.2 de
C.V. %		4.09	4.60	2.14	5.91	10.22	18.07

*Means followed by different letters within columns are significantly different ($p \leq 0.05$)

Zinc might have a positive effect on the photosynthetic activity of leaves (Welch, 1995), which enhances the mobilization of photosynthetic assimilates and directly affected the boll weight. In addition, zinc was required for the synthesis of tryptophan, a precursor of indole-3-acetic acid (Oosterhuis et al., 1991). This is the main hormone that prevents the separation of bolls and bract leaves of the plant. Thus, this increases the number of bolls in the plant, consequently, the seed cotton yield (Rathinavel et al., 2000).

Similar findings suggested that zinc and phosphorus applications increased the seed cotton yield (Sharma and Gupta, 1988; Sawan et al., 1997, 2001; Soomro et al., 2000; Elwan et al., 2002; Mamatha, 2007; Ahmad et al., 2009; Ahmed et al., 2010; Saleem et al., 2010; Emara, 2016; Sawan, 2018).

Plant Height (cm)

Table 4 showed that the lowest plant height in 2011 was obtained from the control plot of P_0 x Zn_0, with 74.4 cm and the highest plant height was provided by the P_{80} x Zn_5 interaction with 82.4 cm, while the lowest plant height in 2012 was obtained from the plot P_{80} x Zn_0 with 64.2 cm and the highest plant height was provided by the control plot of P_0 x Zn_0 and the plot of P_{80} x Zn_5 interaction with 73.8 cm and 73.3 cm, respectively.

The results revealed that phosphorus and zinc had a statistically significant effect on plant height. The P_{80} x Zn_5 interaction taking the first rank in both years indicated that this treatment increased plant height. This result is supported by the Neilsen and

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Hogue's (1986) finding claiming that in phosphorous-rich soils phosphate had low solubility forms, such as the compound $Zn_3(PO_4)_3$ which prevents the transport of zinc to the above-ground organs of the plant, hence, the growth decreases due to the lesser amounts of Zn in the plant tops. Ören and Başal (2012) and Mamatha (2007) observed that zinc applications and Saleem et al. (2010) observed that P applications increased plant height compared to control.

Monopodial Branches (Per Plant)

Table 4 showed that some statistically significant differences were found in both years of experiment in terms of the number of monopodial branches. In 2011, the lowest number of monopodial branches was in P_{80} x Zn_{15} (0.7 per plant) interaction and the highest number was in P_{80} x Zn_{10} (1.4 per plant) and P_{120} x Zn_5 (1.4 per plant). In 2012, the lowest number of monopodial branches was obtained from P_0 x Zn_5 (0.1 per plant) interaction, while the highest number of monopodial branches was obtained from P_0 x Zn_0 (0.5 per plant) interaction.

In terms of the number of monopodial branches, statistically significant differences were found in both years of experiment. Nonetheless, this difference was not stable but varied depending on years. The difference between the experimental years might be due to soil properties and climatic conditions in the experimental years. Saleem et al. (2010) reported that 90 kg ha^{-1} P application decreased the number of monopodial branches compared to the control.

Sympodial Branches (Per Plant)

Statistically significant differences were in 2011, but no difference was found in 2012. The lowest number of sympodial branches in 2011 was from the P_{40} x Zn_0 (11.5 per plant), while the highest number of that was from the P_{120} x Zn_{15} (14.77 per plant) and P_0 x Zn_5 (14.4 per plant) interactions, whereas in 2012, the lowest number of sympodial branches was obtained from the interaction of P_0 x Zn_5 (7.1 per plant), while the highest number of sympodial branches was obtained from P_8 x $Zn_{0.5}$ and P_8 x Zn_1 (11.2 per plant) interactions (*Table 5*).

The results indicated that phosphorus and zinc applications were important in 2011 but they were non-significant in 2012 for sympodial branches, and this difference derived from climate and soil conditions. This showed that there was no stability derived from the effects of phosphorus and zinc on the number of sympodial branches. Ahmad et al. (2009) and Mamatha (2007) reported that zinc applications, both 34 kg ha^{-1} and 50 kg ha^{-1} increased the number of sympodial branches per plant compared to control.

Number of Bolls (Per Plant)

From *Table 5*, it is evident that the lowest number of bolls occured from P_{40} x Zn_0 (12.7 per plant) interaction and the highest number from P_{80} x Zn_{10} (17.7 per plant) interaction in 2011, while in 2012, the lowest number of bolls was obtained from P_{40} x Zn_5 (8.8 per plant) interactions and the highest number was obtained from P_{80} x Zn_5 (11.40 per plant) and P_{80} x Zn_{10} (11.0 per plant) interactions.

These results revealed that phosphorus and zinc interaction had a statistically significant effect on the number of bolls and the highest effect was obtained from the interactions of P_{80} x Zn_5 and P_{80} x Zn_{10}. Phosphorus and zinc applications can lead to an

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increase in the number of bolls by having a positive effect on flower formation and fertilization biology. The results in the current study number of bolls was similar to that from Prasad and Prasad (1994), Sawan et al. (1997), Soomro et al. (2000), Sawan et al. (2008), and Emara (2016). Furthermore, Ahmad et al. (2009) reported that phosphorus application of 34 kg ha^{-1} increases the number of bolls and Mamatha (2007) showed that 50 kg ha^{-1} of zinc application increased the number of bolls by 18.88% compared to control.

Table 5. *Means and the groups of sympodial branches (no. plant^{-1}), number of bolls (per plant) and boll weight (g)*

P X Zn Interactions		Sympodial Branches (per plant)		Number of Bolls (per plant)		Boll Weight (g)	
		2011	2012	2011	2012	2011	2012
P_o	Zn_0	13.8 ab*	11.0 ns	15.9 abc*	9.4 de*	6.2 ns	5.9 ns
	Zn_5	14.4 a	7.1	15.2 a-d	9.1 ef	6.3	6.0
	Zn_{10}	13.7 ab	10.3	15.4 abc	9.8 cd	6.4	6.1
	Zn_{15}	13.5 ab	10.9	15.3 abc	9.8 cd	5.9	6.2
P_{40}	Zn_0	11.5 c	10.7	12.7 d	9.1 ef	6.6	6.0
	Zn_5	13.2 abc	10.4	15.1 a-d	9.7 cd	6.5	6.4
	Zn_{10}	12.3 bc	10.2	14.0 cd	8.8 f	6.1	6.1
	Zn_{15}	13.2 abc	10.5	15.2 abc	10.2 bc	6.1	6.0
P_{80}	Zn_0	13.3 abc	9.7	16.9 ab	9.7 cd	6.1	6.3
	Zn_5	13.4 ab	11.2	16.8 ab	11.4 a	6.4	6.3
	Zn_{10}	13.1 abc	11.2	17.7 a	11.0 a	6.1	6.1
	Zn_{15}	13.0 abc	9.4	16.5 abc	10.4 b	6.3	6.1
P_{120}	Zn_0	13.8 ab	10.3	15.1 a-d	9.9 bcd	6.3	6.4
	Zn_5	14.0 ab	9.3	15.6 abc	9.1 ef	6.4	5.9
	Zn_{10}	13.1 abc	9.7	14.8 bcd	9.9 cd	6.2	6.4
	Zn_{15}	14.7 a	9.8	15.1 a-d	8.7 f	6.4	6.4
C.V. %		4.41	6.63	5.38	8.88	4.29	6.86

*Means followed by different letters within columns are significantly different ($p \leq 0.05$) ns non-significant

Boll Weight (g)

In 2011 and 2012, no significant effect of phosphorus and zinc on the weight of bolls was found (*Table 5*). Boll weights ranged from 5.9 to 6.4 g in both years of experiment. Therefore, it can be concluded that phosphorus and zinc had no significant effect on the weight of bolls in the present study.

Nonetheless, these results in terms of boll weight contradict partially with that of Soomro et al. (2000), Mamatha (2007), and Emara (2016) regarding zinc applications increase the weight of bolls. This may be due to the various cultivars employed in the study and zinc and phosphorus doses used in the trials.

Boll Seed Cotton Weight (g)

In both years, no statistically significant effect of phosphorus and zinc applications on the weight of boll seed cotton was found (*Table 6*). Boll seed cotton weights varied from 4.8 g to 5.4 g. These results showed that phosphorus and zinc had no significant effect on the weight of boll seed cotton.

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Ginning Outturn (%)

From *Table 6*, no statistically significant effect of phosphorus and zinc on ginning outturn was found in 2011 and 2012. The ginning outturn in 2011 and 2012 varied from 40.8 to 42.3%. These results revealed that phosphorus and zinc had no a significant effect on ginnıng outturn.

Table 6. *Means and the groups of boll seed cotton weight (g), ginning outturn (%) and 100 seed weight (g)*

P X Zn Interactions		Boll Seed Cotton Weight (g)		Ginning Outturn (%)		100 seed weight (g)	
		2011	2012	2011	2012	2011	2012
P_o	Zn_0	4.9 ns	4.7 ns	41.7 ns	41.9 ns	9.9 b*	9.9 ns
	Zn_5	4.9	4.6	41.7	41.8	9.9 b	9.9
	Zn_{10}	5.0	4.8	41.4	41.6	9.9 b	10.3
	Zn_{15}	4.9	4.9	41.5	42.3	9.6 b	9.6
P_{40}	Zn_0	5.2	4.7	41.2	41.5	9.6 b	9.6
	Zn_5	5.2	5.4	41.2	40.8	9.9 b	9.6
	Zn_{10}	4.8	4.8	41.4	42.1	9.8 b	10.3
	Zn_{15}	4.8	4.7	41.8	42.1	9.5 b	9.8
P_{80}	Zn_0	5.0	4.6	42.0	42.3	9.4 b	9.8
	Zn_5	5.0	5.0	42.2	41.9	9.9 b	9.8
	Zn_{10}	4.9	4.8	41.1	41.0	10.0 b	9.7
	Zn_{15}	5.0	4.8	41.4	41.0	9.8 b	10.0
P_{120}	Zn_0	5.0	5.1	41.9	41.7	10.1 ab	10.0
	Zn_5	5.1	4.6	41.3	42.2	9.7 b	9.5
	Zn_{10}	5.0	5.1	41.1	42.4	9.9 b	9.5
	Zn_{15}	5.0	5.1	42.0	41.7	10.7 a	10.6
CV %		3.37	8.41	1.62	2.16	2.11	6.57

*Means followed by different letters within columns are significantly different ($p \leq 0.05$) ns non-significant

Similar results were reported by Emara (2016) that zinc had no significant effect on ginning outturn. However, Mamatha (2007) observed that zinc application increased the ginning outturn while Ahmad et al. (2009) reported that phosphorus had little effect on ginning outturn. This might be due to the differences in the plant material and the doses of zinc and phosphorus used in the experiments. In addition, climatic conditions might affect the formation and development of fibers and might influence the formation of various Zinc and P ginning outturns.

100 Seed Weight (g)

It was observed in *Table 6* that there were differences among factors affecting 100 seed weight only in 2011 but not in 2012. In 2011, the lowest 100 seed weight was obtained from the interaction of P_{80} x Zn_0 (9.4 g) and the highest 100 seed weight from the interaction of P_{120} x Zn_{15} (10.7 g). In 2012, the 100 seed weight varied from 9.5 g to 10.6 g. The presence of the difference between the years might be due to climate and soil factors. Sawan et al. (2001) and Emara (2016) reported that Zn applications increased 100 seed weight. In this case, the increase in 100 seed weight might be due to increasing photosynthesis activity by Zn application (Welch, 1995).

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Conclusion

Mineral nutrients are one of the most important factor affecting plant growth by contributing the formation of dry matter by affecting the biochemical processes occurring in plants. It was found that phosphorus and zinc management had a significant effect on seed cotton yield, plant height, number of bolls, and number of monopodial branches in both years of the experiment. Both plant nutrients had significant effect on the number of sympodial branches and 100 seed weight only in the first year but not in the second year. These inputs had no significant effect on boll weight, boll seed cotton weight, and ginning outturn in both years.

It was concluded that, depending on the distribution of plant nutrients in the soil, 80-100 kg of phosphorus and 10-15 kg of Zinc applications per hectare can increase in seed cotton yield. Validity of these results must be verified via multi location tests in future studies.

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