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Effect of Foliar Application of Zinc and Soil Phosphorus Rates on Guava Seedlings Growth and Nutrients Uptake.

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ABSTRACT

A field experiment was conducted in private farm Damietta governorate, Egypt to study the effect of zinc treatments (0.0, 0.2, 0.4, and 0.6%) as a foliar application and phosphorus fertilizer rates (0, 300 and 600g P_2O_5/plant) and their interaction on the growth, nutrient content and uptake of guava (Psidium Guajava L.) seedlings. Zinc treatments were added 4th times one month between every foliar application. Treatments were arranged in a split block design with three replicates. Plant height, stem diameter, leaves number/ plant, fresh and dry weight, N, P, K and zinc uptake were determined. All the previous parameters significantly were affected by phosphorus rates, zinc levels and their interactions. Obtained data show that the higher phosphorus rate (600 g P_2O_5/plant) recorded the highest values of all previous parameters except potassium uptake by seedlings leaves. In addition, the treatment of 0.6 % zinc gave the maximum values of zinc, potassium, phosphorus uptake, dry and fresh weight over the control treatment. These results may be due to low available phosphorus and zinc in soil. The highest nitrogen, phosphorus and potassium uptake values in both samples (after two and four months) were found at the treatment of 600 g P_2O_5/plant combined with 0.2% zinc. Finally, it concluded that using zinc as a foliar application and soil addition of phosphorus fertilizer rates improved guava seedlings growth and nutrients uptake.

Keywords: guava seedling, zinc, phosphorus rates, growth, nutrients uptake

INTRODUCTION

Guava (*Psidium guajava* L.), is the most popular fruits grown in Mediterranean Basin. Guava is widespread in Egypt as well as in the world. Recently, its trees were died or its production reduced in big areas especially in Damietta governorate. It could be regarded to many reasons such as fungal infection, nematode infection, high water table level, bad water drainage and nutrient deficiency, especially in sandy soil. The nutrients deficiency is the most widespread symptom chiefly of people interest with nitrogen fertilizers and no care with the other nutrient. Many workers have reported the effect of zinc and phosphorus nutrients on guava plant growth and yield. Zinc plays a vital role in the production of natural auxin especially 'Indole-3-acetic acid' (Cakmak *et al.,* 1989), act as a catalyst in the metabolism of the plants and as enzyme activator in the oxidation-reduction process (Mousavi *et al.*, 2007). It is related to indirect involvement in regulation of water in plants, the formation of chlorophyll, development of green colour of leaf (Samolodos, 1964), activate phosphate transferring enzyme in plants (Pandey *et al.*, 2006). In guava, usual symptoms of zinc deficiency are interveinal chlorosis, sparsity of foliage, fatio disease, and reduced leaf size and fruit production. (Pedler *et al.*, 2000).On the other hand, zinc affected guava plant growth, production and leaf nutrient content. Phosphorus is a constituent of all plant tissues and is found especially concentrated in younger parts and in flowers and the seed. In addition, phosphorus is important in germination of seeds, stimulation root growth, seeds ripening process, cell division and meristematic tissue development. Phosphorus deficient appeared as small growth, small Leaves, flowering reduced and delayed fruit maturity (Dhakar, 2014). This study aimed to investigate the effects of foliar application of zinc on guava seedlings under different phosphorus fertilization rates.

MATERIALS AND METHODS

A field experiment was carried out on one-year-old seedlings (Psidium guajava L.) of guava cv. Local guava planted at 4x5 m distance at a private farm, Damietta governorate, Egypt to evaluate the effect of zinc levels as a foliar spray and phosphorus fertilization rates on guava seedlings growth and nutrient contents. The soil used in the experimental site was sandy loam texture and the physical and chemical analysis was found in Table (1).

Table 1. Physical and chemical properties of the experimental soil.

$CaCO_3$ %	pH (1:2.5)susp.	EC (dSm^{-1})	Field capacity %	Saturation Percent (%)	Available nutrients (mg/kg) N	P	K	zn
1.70	7.85	3.62	16	32.6	31.20	4.00	66.63	0.4
Texture	Coarse sand %	Fine Sand %	Silt %	Clay %				
Loamy Sand	11.63	69.71	6.43	12.23				

The treatments used in this investigation were , zinc levels used at 0.0 %, 0.2%, 0.4 and 0.6 % as a foliar spray in zinc sulphate ($ZnSO_4$) form while, phosphorus fertilizer was added to soil at rate of 0, recommended rate (300 g P_2O_5 / plant) and twice recommended rate (600 g P_2O_5/ plant) as single super phosphate (7 % P) and their interactions.The seedlings were sprayed with different concentrations of zinc sulphate ($ZnSO_4$) four times beginning at the first of June and repeated every month at a rate of 200 L/Feddan. Phosphorus fertilizers rates were added in two doses, the first one at the beginning of the experiment and the second one after one month.

Leave samples were taken after the second foliar spray by one week (after 2 months) and another sample was taken after one week from the fourth application (after 4 months). Plant height (cm), stem diameter (cm) and leaves number were determined after a week from the second and the fourth foliar application.

Preparation of leave samples: Leaves fresh weight of samples were taken before they were kept in oven at 70 °C for 36 hrs to get constant dry weight, then grind and digested by a sulfuric – perchloric acid mixture for N, P and k and another plant sample was digested by nitric acid for zinc determination as described by Cottenie *et al.* (1982).

Zinc was determined in digested solution by Atomic absorption spectrophotometer. The results were expressed in mg kg^{-1} (Lindsay and Norvell, 1978).

N, P, and K uptake were calculated separately by the following formula: Nutrient uptake in kg fed^{-1} = Nutrient % in leave samples *dry matter /100 (Sharma, *et al.* 2012).

Soil analysis

Particle size.distribution was.determined using the international.pipette method as described by Haluschak (2006). Electrical.conductivity and soil pH values were determined in soil suspension as described by Carter and Gregorich (2007). Field capacity.and saturation.percentage were determined as described by Black, (1965). Soil nitrogen was extracted by using 2.0 N KCl according to van Reeuwijk (2002) to determine the available nitrogen.using half automatic kjeldhal apparatus. While the soil was extracted by using 0.5 N $NaHCO_3$– at pH, 8.5 according to van Reeuwijk (2002) to determine .available .phosphorus.in this.extraction. Available potassium in the soil.was extracted.by using 1.0 N $(CH_3)COONH_4$ at pH 7according.to Hesse (1971) and estimated by using the Flame photometer model PFP7.

Statistical analysis

All data were statistically analyzed according to the technique of analysis, variance (ANOVA) ,.the least significant difference (LSD) method and correlation coefficient analysis was used to compare the differences between the means of studied treatments values according. to methods described by Gomez and Gomez (1984). All measured investigations were performed. utilizing a examination fluctuation procedure by method of CoSTATE PC programming.

RESULTS AND DISCUSSION

Results in Table (2)show that guava plant height (cm) significantly increased by increasing phosphorus rate where it increased by 10.35 and 14.92 % at the first leaves sample and by 7.51 and 15.51 % at the second leaves sample with the phosphorus rate of 300 and 600 g P_2O_5 plant $^{-1}$ respectively, compared with the control treatment. This result may be due to phosphorus role in cell division and meristematic tissue development. These results are in agreement with those of Sharma, *et al* (2014).

Table 2. Effect of phosphorus and zinc treatments and their interactions on guava seedlings plant height and stem diameter after two and four months from the beginning of the experiment.

Treatment	Plant height 1 (cm) After 2 months	Plant height 2 (cm) After 4 months	Relative Plant height growth	Stem diameter 1 After 2 months	Stem diameter 2 After 4 months	Relative Plant height growth Cm day^{-1}
P0	56.41	72.16	0.16	1.02	1.58	0.009
P1	62.25	77.58	0.35	1.16	1.84	0.011
P2	64.83	83.41	0.30	1.10	1.72	0.010
LSD at 5%	2.41	1.74	0.013	0.003	0.18	Ns
Zn0	55.66	73.44	0.31	0.98	1.66	0.011
Zn1 (0.2%)	56.88	74.66	0.27	1.10	1.84	0.012
Zn2 (0.4%)	69.66	83.33	0.22	1.18	1.72	0.009
Zn3 (0.6 %)	62.44	79.44	0.28	1.14	1.66	0.008
LSD at 5%	2.18	2.21	0.05	0.04	0.048	0.0009
P0 Zn0	45.00	56.00	0.18	0.80	1.36	0.009
P0 Zn1	58.00	64.66	0.11	1.00	1.60	0.01
P0 Zn2	82.00	90.00	0.13	1.06	1.58	0.009
P0 Zn3	64.00	78.00	0.23	1.26	1.82	0.009
P1 Zn0	58.00	83.00	0.41	1.00	1.80	0.013
P1 Zn1	52.00	77.33	0.42	1.44	2.28	0.014
P1 Zn2	60.33	78.00	0.29	1.08	1.72	0.010
P1 Zn3	55.33	72.00	0.27	1.16	1.60	0.007
P2 Zn0	64.00	85.00	0.35	1.14	1.82	0.011
P2 Zn1	60.66	78.33	0.29	0.88	1.66	0.013
P2 Zn2	66.66	82.00	0.25	1.4	1.86	0.008
P2 Zn3	68.00	88.33	0.33	1.02	1.60	0.009
LSD at 5%	3.78	3.839	0.086	0.042	0.042	0.0016

A similar result was found with the zinc levels which significantly increased guava plant height with zinc treatment increasing. The treatment of 0.4 % zinc recorded the highest guava plant height (69.66 and 83.33 cm). These results may be regarded to Zn activates auxins and GAs synthesis, cell division and enlargement (Sekimoto *et al.,* 1997). On the other hand, the interaction between zinc levels and phosphorus rates significantly also increased plant height of guava plant compared with the control treatment (0 Zn and 0 P) and the maximum values (82 and 90cm) were obtained with the treatment of zero phosphorus combined with 0.4 % zinc (P0Zn2).

On the other side, relative plant height (cm day^{-1}) take the same trend with phosphorus treatments and it was reduced with increasing zinc levels compared with the control treatment. The lowest relative plant height was found with the treatment of 0.4 % zinc. These results may be due to high increment in plant height after two months and lower increase plant height after four months compared with control treatment. Meanwhile, the interaction between different treatments significantly increased relative plant height except it was decreased with the treatments of P0 Zn1 and P0Zn2 compared to the control treatment.

Data presented in Table (2) reveal that stem diameter of guava plant significantly increased with increasing phosphorus rate where it increased by 13.72 and 7.84 % after two months and by 16.45 and 8.86% after 4 months, with the phosphorus rate of 300 and 600 g P_2O_5 $plant^{-1}$ compared to the control treatment. This result may be due to phosphorus role in cell division and meristematic tissue development. The same trend was found with increasing zinc level and the highest guava stem diameter (1.18 and 1.82 cm) was found with the zinc level of 0.4 % zinc. These results may be due to zinc effects on translocation of amino acids and sugars and enhancing photosynthesis process in the plant (Cakmak *et al.,* 1989). On the other hand, guava stem diameter significantly increased as affected by the interaction between phosphorus rate and zinc levels. The highest stem diameter value was recorded at the treatment of 600 g P_2O_5 $plant^{-1}$ combined with .0.4% zinc in both samples (after 2 and 4 months).

Table 3. Effect of phosphorus and zinc treatments and their interactions on guava seedlings fresh and dry weight after 2 and four months.

Treatment	Fresh weight after 2 months 8 leaves, g	Fresh weight after 4 months 8 leaves, g	Dry weight after 2 months 8 leaves, g	Dry weight after 4 months 8 leaves, g	Leaves number after 2 months	Leaves number after 4 months
P0	11.57	11.69	4.73	7.81	17.75	22.5
P1	11.78	12.81	4.84	8.30	18.75	25.41
P2	11.90	13.01	4.91	8.37	22.25	28.08
LSD at 5%	0.152	0.20	0.067	0.038	2.73	1.46
Zn0	11.38	11.98	4.70	8.06	21.11	26.66
Zn1 (0.2%)	12.35	12.45	4.61	8.52	18.11	25.33
Zn2 (0.4%)	12.01	12.26	4.71	7.99	19.77	24.55
Zn3 (0.6 %)	12.26	12.33	5.10	8.67	19.33	24.77
LSD at 5%	0.084	0.196	0.042	0.056	1.13	1.45
P0 Zn0	10.71	10.08	4.41	7.28	18.00	22.00
P0 Zn1	11.16	12.15	4.65	8.41	18.00	22.66
P0 Zn2	12.13	12.00	4.87	7.85	1700	19.00
P0 Zn3	12.28	11.53	5.02	7.71	21.00	26.33
P1 Zn0	11.3	12.90	4.63	8.57	22.00	29.00
P1 Zn1	11.75	12.85	4.70	8.24	18.00	24.00
P1 Zn2	11.51	12.53	4.78	8.13	22.00	26.66
P1 Zn3	12.58	12.97	5.24	8.26	18.00	22.00
P2 Zn0	12.14	12.95	5.06	8.33	23.33	29.00
P2 Zn1	11.15	14.35	6.49	8.92	22.33	29.33
P2 Zn2	12.4	12.25	5.08	8.24	24.33	28.00
P2 Zn3	11.92	12.50	5.02	7.99	19.00	26.00
LSD at 5%	0.146	0.34	0.073	0.097	1.96	NS

In addition, the relative stem diameter growth (cm day^{-1}) significantly affected by all treatments and its interactions except the phosphorus treatments were not significant. The highest relative stem diameter growth (0.014 cm day^{-1}) was recorded at the treatment of 300 g P_2O_5 $plant^{-1}$ combined with 0.2 % Zn. Results in Table (3) illustrate that guava leaves fresh weight (g) after two and four months significantly increased by increasing phosphorus fertilizer rates and zinc levels. These results may be due to zinc effects as an activator to many enzymes involved in photosynthesis, cell division and cell elongation (Safak, 2009).

Meanwhile the interaction between different treatments also significantly increased the fresh weight of guava leaves in both samples (after two and four months). The highest fresh weight values were found at the treatment of 600 g P_2O_5 $plant^{-1}$ with 0.2% Zn after 4 months. On the other hand, dry weight of guava leaves after two and four months significantly increased with increasing phosphorus rates and the maximum dry weight values(4.9 and 8.37g) were found at the phosphorus rate of 600 g P_2O_5 $plant^{-1}$. In addition, it increased also with increasing zinc levels and the treatment of 0.6 % zinc gave the highest values of dry weight (5.09 and 8.67). These results are in line with that of Grewal, 2001 The same trend was found with the interaction between different used treatments. The combination between 600 g P_2O_5 plant^{-1} and 0.2 % zinc recorded the maximum dry weight values (5.49 and 8.92 g) of guava leaves after two and four months.

Data in Table (3) also show that leaves number/ seedling after two and four months significantly increased by increasing phosphorus rate and the phosphorus rate at 600 g P_2O_5 plant^{-1} achieved the highest leaves number of the seedling. These results may be a caused by the phosphorus role in increasing cells divination. In contrast, leaves number/ seedling decreased with increasing zinc levels where the control treatment (Zn0) recorded the highest leaves number/seedling in both samples. Meanwhile, the interaction between different treatments had not a constant trend effect on leaves number/ seedling.

Nutrient uptake by seedling leaves (mg /plant leaves)

Data in Table(4)show that zinc content(mg kg^{-1}) and zinc uptake after two and four months significantly increased with increasing phosphorus rate and the highest zinc uptake values were recorded at the treatment of 600 g P/plant. These results may be regarded to lower available phosphorus and zinc in soil. These results are in agreement with those obtained by Soltangheisi, (2014). While Salimpour *et al*., 2010 and Novais et al.(2016) they found that excessive accumulation of phosphorus, caused zinc imposed deficiency. A similar trend was found with the zinc levels, where the foliar spray of zinc by 0.6 % zinc recorded the highest zinc uptake values compared with control treatments. These results are in line with those of Carolina *et al*., 2011. Meanwhile, the interaction between different treatments significantly increased zinc uptake over the control treatment. The maximum zinc uptake values (12.14 and 30.21 mg /seedling leaves)were recorded at the integration between 600 g P_2O_5 plant^{-1} and 0.6% zinc

Table 4. Effect of phosphorus and zinc treatments and their interactions on zinc content and zinc uptake of guava leaves after 2 and four months.

Treatment	Na uptake after 2 months	Na uptake in after 4 months	Zn content after 2 months	Zn content after 4 months	Zn uptake after 2 months	Zn uptake after 4 month
	mg/ seedling leaves		Mg kg^{-1}		mg/ seedling leaves	
P0	131.7	232.1	221.50	293.57	7	14.45
P1	91.5	266.2	255.66	308.17	7.28	16.61
P2	115.4	325.9	215.88	272.23	7.91	16.00
LSD at 5%	8.17	30.43	1.427	1.426	NS	0.769
Zn0	73.5	302.4	118.07	132.31	4.13	7.55
Zn1 (0.2%)	120.9	275.6	202.75	241.55	6.04	13.46
Zn2 (0.4%)	126.2	247.7	258.94	282.69	8.90	14.73
Zn3 (0.6 %)	130.9	273.1	300.96	508.42	10.51	27.011
LSD at 5%	8.8	2.38	1.017	1.167	0.380	0.742
P0 Zn0	99.3	239.2	100.09	115.43	2.86	5.05
P0 Zn1	71.7	175.5	170.69	263.23	5.16	13.58
P0 Zn2	167.8	235.3	240.81	281.37	6.43	11.94
P0 Zn3	187.9	278.4	322.43	510.25	11.53	27.23
P1 Zn0	52.5	228.0	111.31	175.97	3.88	11.12
P1 Zn1	128.2	302.4	231.56	280.05	6.00	14.79
P1 Zn2	82.2	270.6	270.32	300.67	9.38	16.96
P1 Zn3	103.0	263.7	285.46	475.02	9.85	23.58
P2 Zn0	68.7	440.0	142.82	115.54	5.65	6.49
P2 Zn1	162.6	349.0	204.00	180.3	6.97	12.00
P2 Zn2	142.8	237.4	255.71	265.03	10.89	15.30
P2 Zn3	87.7	277.3	240.01	530.99	12.14	30.21
LSD at 5%	15.2	41.3	1.762	2.021	0.658	1.285

Results in Table (5) declare that nitrogen, phosphorus and potassium uptake by guava seedling significantly increased by increasing phosphorus rate compared with control treatment. These results are in the same line with Kadam and Patil (1993), Natale *et al.* (2000). The phosphorus rate at 600 g P_2O_5 plant^{-1} recorded the maximum nitrogen and phosphorus uptake values after two and four months. In addition zinc treatments also significantly increased nitrogen, phosphorus and potassium uptake with increasing zinc levels and the zinc level at (0.2%) gave the highest nitrogen uptake values (383 and 685.3 mg/ seedling leaves). These results may be regarded to activating phosphate transferring enzyme in plants and its influence on nitrogen metabolism and uptake of nitrogen and protein quality (Alloway, 2008).These results are in agreement with that of Nijjar and Brar (1977) while the maximum phosphorus and potassium uptake values were recorded at the foliar application of 0.6 % zinc.

A similar trend was found with the interaction between phosphorus rates and zinc levels, where nitrogen, phosphorus and potassium uptake were increased with the interaction between the treatments. The highest nitrogen, phosphorus and potassium uptake values in both samples (after two and four months) were found at the treatment of 600 g P_2O_5 plant^{-1} combined with 0.2% zinc. These results may be a cause by increasing leaves dry weight and nutrient content in this treatment as a result of the balance between phosphorus and zinc at this rate.

Table 5. Effect of phosphorus and zinc treatments and their interactions on nitrogen, phosphorus and potassium uptake of guava leaves after 2 and four months from the beginning of the experiment.

Treatment	K uptake after 2 months	K uptake after 4 months	P uptake after 2 months	P uptake after 4 months	N uptake after 2 months	N uptake after 4 months
	mg/ seedling leaves		mg/ seedling leaves		mg/ seedling leaves	
P0	246.3	581.5	15.7	32.00	305.7	531.4
P1	246.7	687.3	23.2	43.57	330.0	662.72
P2	265.9	681.7	27.3	54.18	373.4	751.35
LSD at 5%	NS	3.16	1.28	4.18	33.7	57.9
Zn0	229.5	563.6	20.4	36.91	355.1	598.2
Zn1 (0.2%)	229.6	684.4	20.4	40.33	383.0	685.3
Zn2 (0.4%)	260.0	638.0	22.8	40.72	344.1	650.0
Zn3 (0.6 %)	292.9	714.6	24.9	45.05	363.3	660.3
LSD at 5%	14.3	4.04	2.1	3.2	23.8	38.4
P0 Zn0	232.3	428.5	11.8	24.7	301.0	505.6
P0 Zn1	244.4	609.1	18.3	35.6	386.1	605.6
P0 Zn2	274.4	627.5	14.6	27.8	391.4	478.0
P0 Zn3	235.8	661.0	18.3	39.9	344.4	536.4
P1 Zn0	300.5	595.0	24.1	38.9	377.4	761.0
P1 Zn1	203.7	742.0	18.2	47.8	326.5	627.5
P1 Zn2	259.0	697.0	25.9	41.4	363.7	605.6
P1 Zn3	322.2	715.2	24.8	46.0	352.5	656.7
P2 Zn0	247.3	667.4	25.3	47.1	387.0	683.4
P2 Zn1	293.4	702.1	28.3	67.5	409.0	822.7
P2 Zn2	255.5	589.9	28.1	52.9	377.3	711.1
P2 Zn3	320.8	767.7	31.8	49.2	393.1	788.0
LSD at 5%	24.8	70.0	3.6	5.7	41.3	66.6

CONCLUSION

Finally, zinc level and phosphorus treatments and their interactions significantly affected guava seedling growth. Phosphorus rate at 600 g P_2O_5 plant^{-1} significantly increased most of the studied parameter while the zinc level at 0.6 % significantly improved nutrients uptake by guava seedlings.

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تأثير استعمال الزنك رشا ومعدلات الفوسفور أرضا علي نمو شتلات الجوافة والعناصر الغذائية الممتصة ٠

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أقيمت تجربة حقلية لدراسة تأثير الرش بالزنك (صفر،٢و٠ ،٤و٠ ،٦و٠% زنك وزن / حجم) و معدلات الفوسفور (صفر ، ٣٠٠ ، ٦٠٠ جم / خامس أوكسيد الفوسفور نبات) والتفاعل بينهم علي نمو شتلات الجوافة وكذلك العناصر الممتصة ٠ صممت التجربة في القطع المنشقة مرة واحدة في ثلاثة مكررات ٠ وقد تم تقدير وقياس كلا من طول النبات (سم) و متوسط قطر الساق (سم) وعدد الأوراق/ النبات و الوزن الجاف والطازج للعينات و النتروجين والفوسفور والبوتاسيوم والزنك الممتص ٠أظهرت النتائج المتحصل عليها أن جميع الصفات السابقة تأثرت معنويا بمعدلات الفوسفور والزنك والتفاعل بينهم وتبين النتائج المتحصل عليها أن اضافة الفوسفور بمعدل ٦٠٠ جرام خامس أوكسيد الفوسفور /نبات قد سجل أعلي القيم للصفات المدروسة ما عدا البوتاسيوم الممتص بواسطة أوراق شتلات الجوافة ، إضافة الي ذلك سجلت معاملة الرش ب ٦و٠% زنك اعلي قيم للفوسفور والبوتاسيوم والزنك الممتص بواسطة أوراق شتلات الجوافة والوزن الطازج والجاف مقارنة بالكنترول٠ ويمكن ارجاع هذه النتائج الي استجابة الشتلات وانخفاض محتوي التربة من الفوسفور والزنك الميسر٠ سجل التداخل بين ٦٠٠ جرام خامس أوكسيد الفوسفور /نبات و ٢و٠% زنك أعلي قيم للفوسفور والنيتروجين والبوتاسيوم الممتص في كلا العينتين (بعد شهرين وأربعة أشهر من بداية المعاملات) ٠ في النهاية نستنتج أن استخدام الزنك رشا ومعدلات الفوسفور أرضي حسنت من نمو شتلات الجوافة والعناصر الغذائية المتصة ٠