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Influence of foliar spray of different calcium sources on nutritional status, seed yield and quality for some peanut genotypes

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Two field experiments were carried out at Ismailia Agricultural Research Station during 2016 and 2017 summer growing seasons to determine the best sources of calcium for obtained the best nutrient status and the highest seed yield of three peanut genotypes (Line 8, Line 1 and Ismailia 1).The experiment was laid out using split-plot design arrangement with three replicates. Recommended dose of soil calcium application alone as control and its combination with foliar spray of three different calcium sources {calcium chloride 36% Ca, calcium nitrate 19.5 % Ca, and calcium sulfate 22% Ca. Significant influences of foliar spray of different calcium sources were observed on all studied parameters in both growing seasons and their combined analysis. The foliar spraying of calcium sulfate was appeared to be the super since, it recorded the best results. Here too, peanut genotypes studied were varied significantly in all studied traits in both seasons and their combined analysis. There was significant effect of the interaction between peanut genotypes and calcium foliar spraying of different sources on all parameters studied. Ismailia 1 cultivar gave the highest values for nutrient contents in leaves, plant height, weight of pods/plant, 100-pod weight, weight of seeds/plant and dry weight of leaves/plant, when foliar with calcium sulfate 36% Ca foliar spray. Based on two years results, it could be concluded that application of calcium sulfate 36% Ca as a foliar spray might be the best for crop nutrients status, pods yield and its components under sandy soil condition, at Ismailia. . Moreover, the importance of selection for No. of seeds plant^{-1} and No. of pods plant^{-1} to their direct and indirect impact on seed weight plant^{-1}

Keywords: Peanut, Calcium, Foliar Spray, Nutritional Status, Seed Yield and Quality

INTRODUCTION

Peanut is considered one of the most important leguminous crops in Egypt. Peanut was grown in Egypt for fresh human consumption, oil production or export, since its cultivation is thrived in the reclaimed sandy soil. Therefore, great emphasis should be given towards an improvement of peanut production. Consequently, cultivating promising genotypes with high yielding ability and favorable applying agricultural practices such as foliar calcium application offer a great opportunity to improve seed yield and oil quality of peanut.

In this connection, calcium deficiency will result in unfilled pods and lowered quality of peanuts. So application of calcium is necessary for pod growth and increased peg strength. David et al., (2001) found that calcium increased pod yield and improves market grade factors. It is important for pod development, seed filling and crop performance (FAO, 1984 and Baughman and Dotray, 2015). Foliar feeding is often effective when roots are unable to absorb sufficient nutrients from the soil.

Calcium considered a key role in fruit set stag and when calcium have been applied before flowering, it will cause an increase in flowering and fruit set, which may be due to the high need of plant at this stage to sufficient concentrations of calcium for the integration nutrients and balance El-Dahshouri, et al., (2017). Calcium play an important role in many biochemical processes and controlling physiological disorders (Favaro, et al., 2007), Also, calcium has been described as essential element to the maintenance of cell membranes and walls because it is involved in links with pectin substances that help the cell to cell adhesion (Hepler& Wayne, 1985), and described as essential for plant nutrition, where Plant growth, seed quality and length of storage after harvest increases because of calcium addition not due to effect of calcium addition but also, due to important role played by calcium in balances solution in plant and soil.

Depending on importance of nutrients, foliar spraying of plants is consider effective by four or three times than soil application, and many reported that plants growing with high concentrations of calcium produced highest dry weight of the shoot Favaro et al., (2007).

The application of Calcium ($CaCO_3$) is important for proper kernel development in groundnut. Calcium carbonate can be used as a calcium source, but, compared to Gypsum; it is slow releasing due to less solubility. Therefore, Gypsum ($CaSO_4$- $2H_2O$) can be used at flowering to ensure the adequate availability of Cain the fruiting zone to enhance the pod development. Chapman et al., (1993) reported that the less amount of soluble calcium in the pegging zone cause low peg formation. Many researchers found that the groundnut pegs and pods treated with gypsum had a significantly less pod root, than the untreated (Chapman et al., 1993).

On the other wise, many investigators found significant variation between peanut genotypes in growth, yield, yield components and quality due to the differences in genetic structure and their interaction with environmental condition prevailing during growing season (Meena et al., 2014; Mahrous et al., 2015 and Sarkees, 2015).

The objective of this study was to determine the best source of foliar calcium to achieving best nutrient status and the highest seed yield of three peanut genotypes, besides to determine the relationships between yield and its related traits using simple correlation coefficient and path analysis as selection criteria for improving yield of peanut genotypes.

MATERIALS AND METHODS

Two field experiments were carried out at Ismailia Agricultural Research Station during 2016 and 2017 summer growing seasons to investigate the effect of foliar applications with three different sources of calcium (Ca) i.e. on seed nutrient contents, seed yield and its related traits of three peanut genotypes (Line 8, Line 1 and Ismailia 1) in sandy soil.

The experimental design was split plot with four treatments. The three calcium treatments plus control (tab water) were assigned in main plot while the sub plots were allocated by three peanut genotypes which received from Oil Crops Research Department, Agricultural Research Center (ARC), Egypt.

The treatments were:

-Control (water)
-Calcium chloride 36% Ca.
-Calcium nitrate19.5 % Ca.
-Calcium sulfate 22% Ca at.

Calcium sources were applied as foliar application two times with the different assigned treatments starting after 50 days from sowing and repeated after 15 days from the last one.

The whole experimental plots were also sprayed with mixed micronutrients compound containing (Fe, Mn and Zn) in EDTA form two times (45 and 60 days after sowing) at rate of 0.5 g/L.

Soil analysis:

Some physic-chemical properties of soil sample from experimental sites 2016 and 2017 are presented in Table 1 using method as described by Jackson (1986).

Nutrient elements analyses in leaves

Dry weight, macro- and micronutrient contents in leaves were determined in plant sample taken at 90days after sowing.

The plant samples washed, dried, grinded and digested to determine the macronutrients (N, P, K, Ca and Mg mg/plant) and micronutrient (Fe, Zn and Mn µg/plant) contents according to Ankerman and Large (1974).

Table 1: Some physico-chemical properties of soil sample from experimental sites 2016 and 2017.

	Mechanical analysis %			Texture	Physical properties				Macronutrients (mg/100g)					Micronutrients (ppm)			
	Sand	Silt	Clay		pH	E.C (dS/m)	$CaCO_3$ (%)	O.M (%)	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
1st	91.4	5.2	3.4	Sandy	8.2	0.07	1.6	0.4	3.4	35	3.57	1.1	10.7	3.2	3.2	0.8	0.4
2nd	90.6	5.8	3.6		8.4	0.10	1.5	0.4	4.2	35.5	3.47	1.16	10.4	3.6	3.1	0.7	0.3

The experimental unit area was 10.5 m^2 and contained 5 ridges; 60 cm apart and 3.5 m long. Seeds were inoculated with the specific *Rhizobium japonicum* strain prior to sowing. Seeds were sown by hand on one side of the ridges (3-4 seed in each hill) on May 11 and 25 in 2016 and 2017 seasons, respectively. After two weeks of germination, seedlings were thinned to 2 plants $hill^{-1}$. The recommended rate 500 kg calcium sulfate $fed.^{-1}$ was added during soil preparation. Phosphorus fertilizer in the form of mono-calcium super phosphate (15.5% P_2O_5) was added at soil preparation and nitrogen fertilizer was added in the form ammonium nitrate (33.5% kg N $fed.^{-1}$), and potassium fertilizer in the form of potassium sulfate (48 % K_2O).

All recommended of agricultural practices were adopted throughout both growth seasons. At harvest, a sample of five guarded plants was taken randomly from each sub-plot to determine the following characteristics:

a- Vegetative traits:
Stem length (cm).
No. of branches $plant^{-1}$.

b- Yield traits:
No. of pods $plant^{-1}$.
Pod weight $plant^{-1}$ (g)
Seed weight $plant^{-1}$(g)
Seed yield $fed.^{-1}$ (kg)

C- Pod and seed traits:
100- Pod weight (g).
100- Seed weight (g).
No. of seeds $plant^{-1}$
Shelling%

Statistical analysis:

All data collected in this study of each season were analyzed as mentioned by Gomez and Gomez (1984). Homogeneity of variance between two seasons was checked as described by Gomez and Gomez (1984). The proper combined analysis of variance (over the two seasons) of the split plot design was done according to Snedecor and Cochron (1989). Mean separation of treatment effects in this study was accomplished using the least significant difference (LSD) test. Combined data of the two seasons for the studied peanut genotypes under soil and foliar calcium application were employed to calculate correlation and path analysis. The coefficient of correlation between all pairs of the yield and yield attributes, were computed as suggested by Snedecor and Cochron (1989).Finally, path coefficient analysis was done between seed weight $plant^{-1}$ as a dependant variable and yield attributes as independent variables according to the method mentioned by Li (1975).

RESULTS AND DISCUSSION

1-Calcium sources effects

Nutrients content

Data in Table 2 indicated that of N, P, K, Ca, Fe and Zn content in peanut plants show significant response to all the Ca sources foliar applications. It was observed that applying 3.0 kg / fed of calcium sulfate produced the highest D.W (11.0 g/plant) at 90 days after sowing as an average of the two seasons. The addition of calcium resulted significantly increased the most macro and micronutrients content of plant leaves. Foliar application calcium of calcium sulfates with 3.0 kg/fed. gave the highest peanut shoots content from N, P, K, Ca, Mg, Fe, Mn and Zn as compared with other treatments. This might be in part attributed to the favorable effect of calcium on vegetative plant materials which in turn increase nutrient content by plants (Marschner, 1995).

Vegetative traits

Regarding the effect of foliar application of different sources of Ca, data in Table 3 revealed that foliar application of Ca significantly increased the mean values of vegetative traits in peanut as compared with untreated plants. On other words; the highest recorded values were 37.73 and 7.82 for stem length and No. of branches $plant^{-1}$, respectively were realized for the plants treated with foliar calcium sulfate of 3 kg $feddan^{-1}$ compared with the other treatments.

Table 2: Effect of calcium sources on dry weight, macro and micro-nutrients content of peanut plants (Average two seasons 2016 and 2017)

Treatments	D.W	N	P	K	Ca	Mg	Fe	Mn	Zn
	g/plant	(mg/plant)					(µg/plant)		
Control	9.3	135.7	26.6	90.2	218.2	17.0	1882	266	229
Calcium chloride	10.5	164.9	41.9	132.5	294.9	29.2	2218	478	316
Calcium nitrate	10.3	162.0	40.5	138.0	281.1	27.9	2228	479	343
Calcium sulfate	11.0	180.4	49.7	140.9	321.4	31.0	2501	492	375
LSD 5%	0.26	9.3	5.6	7.9	16.3	3.5	86	33	27

Comparing with the control treatment the relative increases for stem length and No. of branches plant^{-1}, respectively were recorded 32.57 and 36.71% due to calcium sulfate spray of 3 kg feddan^{-1}. Correspondence of this trend, other additions of different calcium sources significantly increased mean values of more than those obtained for the untreated plants.

Yield traits

Such effect of the foliar application of different sources of Ca on the mean values of No. of pods plant^{-1}, Pods weight plant^{-1}, Seed weight plant^{-1} and Seed yield feddan^{-1}are presented in Table 3. Data showed that spraying peanut plant with Ca significantly increased the average values of the previously mentioned traits than those obtained for the untreated plants. Comparing with the control treatment as seen in combined analysis, the relatively increases of No. of pods plant^{-1}, Pods weight plant^{-1}, Seed weight plant^{-1} and hence Seed yield feddan^{-1} were 60.97, 48.89, 44.84 and 60.68%% in the same order, again, for the same sources of calcium (foliar calcium sulfate spray of 3 kg feddan^{-1}).

Pods and seeds traits

The obtained data of combined analysis as shown in Table 3 indicated that, the average values of No. of seeds plant^{-1}, 100-seed weight, 100-pods weight and shelling % were significantly increased over the control. Foliar application with calcium sulfate considered as the best calcium sources where gave more seeds, heaviest weight of 100-seed and 100-pods, and highest proportion of shelling. As shown in combined analysis, this best source of calcium granted increases surpassed the control by 79.86, 64.01, 60.68 and 37.13 % for No. of seeds plant^{-1}, 100-seed weight, 100-pods weight and shelling %, respectively. The others foliar spray of calcium sources had the same trend of foliar calcium sulfate spray in terms of significantly increased mean values of the previous traits more than those obtained for the untreated plants. Collectively, it seems from the previous results that when foliar calcium sulfates application was used, it resulting in increasing in all studied traits.

2- Genotypes effect

Nutrients content

Dry weight and nutrients content of peanut genotypes are shown in Table 4. There were significant differences between peanut genotypes dry weight of shoot at 90 days after sowing. The superior shoot dry weight was that of Ismalia 1 and Line 1genotypes. The varietal differences between peanut genotypes may be due to the genetically differences between genotypes concerning partition of dry matter, yield per plant and per unit area (Abd EL–Gawad et al., 1987). The obtained results agreement with Dominguez et al., (2016) and El-Dahshouri, et al., (2017) that dry mass of the shoot and root increased linearly in common bean plants which were grown with high calcium concentration. Data in Table 4 include the macro- and micronutrients content in shoots of different peanut genotypes. This data showed significant differences between genotypes in all nutrients content. Ismalia 1 recorded the highest content of all nutrients. Our results are in the same line with (Quintana et al., 1999).

Vegetative traits

Peanut genotypes recorded significant (P≥0.01) differences for stem length and No. of branches plant^{-1}. Ismailia 1 was behaved as the largest stem being 35.19 cm followed by Line 1, whereas Line 8 was behaved as the shortest one. The same trend of stem length was observed for No. of branches plant^{-1}, where Ismailia 1 gave more branches followed by Line 1.The differences between the tested peanut genotypes may be due to the differences in their genetically constituents.

Table 3: Vegetative, yield, pod and seed traits as affected by different calcium sources in both seasons and their combined analysis

Calcium sources	Vegetative traits						Yield traits								
	Stem length			No. of branches plant^{-1}			No. of pods plant^{-1}			Pods weight plant^{-1}			Seed weight plant^{-1}		
	1st	2nd	Comb	1st	2nd	Comb	1st	2nd	Comb	1st	2nd	Comb	1st	2nd	Comb
Control	27.28	29.63	28.46	4.19	7.24	5.72	18.78	17.87	18.32	53.74	68.74	61.24	46.29	47.87	47.08
Calcium chloride	30.21	32.29	31.25	6.93	7.61	7.27	21.43	21.23	21.33	69.14	74.81	71.98	49.22	55.22	52.22
Calcium nitrate	31.86	34.00	32.93	7.40	7.66	7.53	22.84	24.06	23.45	70.80	79.00	74.90	54.73	57.50	56.12
Calcium sulfate	37.06	38.40	37.73	7.68	7.97	7.82	30.20	28.78	29.49	88.31	94.04	91.18	68.12	68.26	68.19
LSD 5%	1.41	1.77	0.95	0.32	0.17	0.21	1.95	1.16	1.33	1.73	5.79	2.40	4.06	2.75	3.00

Calcium sources	Yield traits			Pods and seeds traits											
	Seed yield feddan^{-1}			No. of seeds plant^{-1}			100-seed weight			100-pods weight			Shelling %		
	1st	2nd	Comb	1st	2nd	Comb	1st	2nd	Comb	1st	2nd	Comb	1st	2nd	Comb
Control	14.23	13.29	13.76	33.07	29.29	31.18	80.09	94.49	87.29	14.23	13.29	13.76	50.40	58.78	54.59
Calcium chloride	16.66	14.41	15.53	37.49	36.64	37.07	88.11	103.99	96.05	16.66	14.41	15.53	56.17	64.27	60.22
Calcium nitrate	18.01	16.61	17.31	39.98	39.87	39.92	103.76	112.00	107.88	18.01	16.61	17.31	60.71	66.71	63.71
Calcium sulfate	22.02	22.19	22.11	60.27	51.89	56.08	139.84	146.48	143.16	22.02	22.19	22.11	72.51	77.20	74.86
LSD 5%	1.05	1.20	0.85	2.78	3.50	1.34	4.14	3.79	2.53	1.05	1.20	0.85	1.77	4.24	1.40

Table 4: Effect of peanut genotypes on dry weight, macro and micro-nutrients content of peanut plants (Average two seasons 2016 and 2017)

Treatments	D.W g/plant	N	P	K	Ca	Mg	Fe	Mn	Zn
		(mg/plant)					(µg/plant)		
Line 8	9.75	166.2	38.8	145.3	267.1	25.7	2082	527	357
Line 1	10.82	156.5	36.5	118.6	308.6	29.6	2302	391	308
Ismalia 1	11.28	184.7	56.8	147.5	321.8	32.8	2562	531	367
LSD 5%	3.9	2.2	1.5	4.7	13.2	2.2	46	7	8

The obtained results are in same tendency with those obtained by (Meena et al., 2014; Mahrous et al., 2015 and Sarkees, 2015).

Yield traits

Significantly ($P \geq 0.01$) differences were detected among peanut genotypes for No. of pods plant^{-1}, Pods weight plant^{-1}, Seeds weight plant^{-1}, g and Seed yield feddan^{-1}, Ardab, as shown in both seasons and their combined analysis in Table5.

Ismailia 1 produced more pods, the heaviest pods and seeds plant^{-1}, and hence the highest seed yield feddan^{-1}followed by Line 1, whereas Line 8 took opposite direction. This is may be due to the genotypic behavior in combination with the environmental conditions. Similar findings were recorded by (Meena et al., 2014; Mahrous et al., 2015 and Sarkees, 2015).

Pod and seed traits

No. of seeds plant^{-1}, 100-seed weight, g, 100-pods weight and Shelling % were revealed significant ($P \geq 0.01$) differences among peanut genotypes, as shown in both seasons and their combined analysis in Table 5. Also, Ismailia 1 surpassed the other tested genotypes and produced more seeds plant^{-1}, the heaviest 100-seeds and pods, and hence shelling % followed by Line 1, whereas Line 8 took opposite trend. This is may be due to the genotypic behavior in interaction with the environmental conditions, which may be suitable for Ismailia 1 genotype than the rest genotypes.

3-Interaction effect

Nutrients content

The interaction between peanut genotypes and Ca foliar applications on dry weight of shoot was significant (Table 6). It is noteworthy to mention that calcium sulfate with 3.0 kg/fed on Ismalia 1 is considered to be the most favorable treatment of all mentioned characters in both growing seasons. Calcium application improved DW and nutrient content (Judrth et al., 1977; Khan et al., 2008 and Zhoori et al., 2009).

The interaction between peanut genotypes and Ca foliar applications effect on nutrient content was significant Table 6. When Ismalia 1genotype foliar fertilized by 3.0 kg Ca/fed. as calcium sulfate recorded superiority for dry weight of shoots as average of two seasons. Also, the highest values of N, P, K, Ca, Mg, Fe, Mn and Zn content were achieved when Ismalia 1 genotype foliar fertilized by 3.0 kg Ca/fed. This might be in part attributed to the favorable effect of calcium to form vegetative plant materials which in turn increase nutrients content by plants. Marschner 1995 reported that foliar application of Ca can greatly enhance plant increase nutrients.

Vegetative traits

The interactive effect of calcium sources with peanut genotypes was significant for vegetative and yield as well as pod and seeds traits as shown in combined analysis in Table 7.

For interaction between calcium sources and peanut genotypes as pooled data in Table 7, peanut plants achieved largest stem, more branches, seeds and pods plant^{-1}, heaviest weight of pods, 100-seed, 100-pods and seeds plant^{-1}, and hence seed yield feddan^{-1}and shelling % when sprayed Ismailia 1 with foliar calcium sulfate spray of 3 kg feddan^{-1}.

4-Yield analysis

Correlation

The matrix of simple correlation among seed weight plant^{-1}and its related characters over the two seasons is presented in Table 8.

Table 5: Vegetative, yield, pod and seed traits as affected by peanut genotypes in both seasons and their combined analysis

Genotypes	Vegetative traits						Yield traits								
	Stem length			No. of branches plant^{-1}			No. of pods plant^{-1}			Pods weight plant^{-1}			Seeds weight plant^{-1}, g		
	1st	2nd	Com.	1st	2nd	Com.	1st	2nd	Com.	1st	2nd	Com.	1st	2nd	Com.
Line 8	29.83	31.98	30.91	6.16	7.39	6.78	21.21	20.68	20.94	62.09	73.58	67.83	50.53	52.83	51.68
Line 1	30.49	32.86	31.68	6.59	7.60	7.10	23.43	22.55	22.99	69.18	78.19	73.68	53.19	57.20	55.20
Ismailia 1	34.48	35.90	35.19	6.90	7.87	7.38	25.30	25.73	25.51	80.23	85.68	82.96	60.06	61.60	60.83
LSD 5%	0.56	0.43	0.33	0.18	0.14	0.13	0.98	0.80	0.72	2.41	3.34	1.57	2.65	1.38	1.78

Genotypes	Yield traits			Pod and seed traits											
	Seed yield feddan^{-1}, Ardab			No. of seeds plant^{-1}			100-seed weight, g			100-pods weight			Shelling %		
	1st	2nd	Com.	1st	2nd	Com.	1st	2nd	Com.	1st	2nd	Com.	1st	2nd	Com.
Line 8	16.44	15.28	15.86	36.63	33.81	35.22	92.97	104.17	98.57	179.93	192.72	186.33	54.55	63.19	58.87
Line 1	17.53	16.25	16.89	43.38	39.55	41.47	95.03	107.01	101.02	188.55	204.77	196.66	60.63	65.59	63.11
Ismailia 1	19.23	18.34	18.78	48.09	44.91	46.50	120.86	131.54	126.20	195.63	211.37	203.50	64.66	71.43	68.05
LSD 5%	0.47	0.85	0.48	2.47	3.12	2.05	3.84	3.86	3.54	3.28	2.20	2.09	0.72	2.91	1.39

Table 6 Effect of interaction between peanut genotypes and calcium sources on dry weight, macro and micro-nutrients content (Average two seasons 2016 and 2017)

Treatments		D.W	N	P	K	Ca	Mg	Fe	Mn	Zn
		g/plant	(mg/plant)					(µg/plant)		
Control	Line 8	8.60	147	28.8	98	236	18.4	2037	288	248
	Line 1	9.95	146	28.5	97	234	18.3	2021	285	246
	Ismalia 1	7.82	114	22.4	76	184	14.4	1588	224	193
Calcium chloride	Line 8	10.62	170	50.5	133	299	31.0	2208	478.2	340
	Line 1	11.13	178	37.9	153	298	29.0	2594	523.4	312
	Ismalia 1	9.83	165	43.3	134	265	26.6	1851	433.3	296
Calcium nitrate	Line 8	11.48	161	51.7	156	321	32.0	2727	528.7	364
	Line 1	10.53	170	31.7	134	308	29.5	2314	506.5	380
	Ismalia 1	10.84	155	38.1	121	289	28.2	2461	401.7	380
Calcium sulfate	Line 8	10.03	149	35.0	102	248	22.4	1934	338.6	250
	Line 1	10.80	168	40.0	143	297	30.3	1998	562.2	367
	Ismalia 1	11.74	206	68.0	160	367	35.0	2751	574.3	411
LSD 5%		0.46	16.1	9.6	13.8	28.2	6	148.1	56.6	46.6

Table 7: vegetative, yield, pod and seed traits of three peanut genotypes in response to different calcium sources interaction with peanut genotypes in both seasons and their combined analysis

Interaction		Vegetative traits						Yield traits								
		Stem length			No. of branches plant^{-1}			No. of pods plant^{-1}			Pods weight plant^{-1}			Seeds weight plant^{-1}, g		
		1st	2nd	Com.	1st	2nd	Com.	1st	2nd	Com.	1st	2nd	Com.	1st	2nd	Com.
Control	Line 8	25.90	28.10	27.00	3.43	6.73	5.08	15.20	16.23	15.72	37.40	65.07	51.23	45.40	43.53	44.47
	Line 1	27.17	29.47	28.32	4.47	7.43	5.95	20.23	18.03	19.13	55.80	69.03	62.42	46.47	49.10	47.78
	Ismalia 1	28.77	31.33	30.05	4.67	7.57	6.12	20.90	19.33	20.12	68.03	72.13	70.08	47.00	50.97	48.98
Calcium chloride	Line 8	29.40	31.77	30.58	6.43	7.57	7.00	20.90	19.33	20.12	68.03	71.27	69.65	47.00	52.43	49.72
	Line 1	30.07	32.20	31.13	6.93	7.57	7.25	20.90	19.33	20.12	68.53	74.13	71.33	49.40	56.10	52.75
	Ismalia 1	31.17	32.90	32.03	7.43	7.70	7.57	22.50	25.03	23.77	70.87	79.03	74.95	51.27	57.13	54.20
Calcium nitrate	Line 8	31.17	32.90	32.03	7.23	7.57	7.40	22.20	19.33	20.77	68.53	77.30	72.92	51.27	56.10	53.68
	Line 1	31.53	33.93	32.73	7.43	7.70	7.57	22.57	25.03	23.80	70.87	79.03	74.95	54.50	57.13	55.82
	Ismalia 1	32.87	35.17	34.02	7.53	7.70	7.62	23.77	27.80	25.78	73.00	80.67	76.83	58.43	59.27	58.85
Calcium sulfate	Line 8	32.87	35.17	34.02	7.53	7.70	7.62	26.53	27.80	27.17	74.40	80.67	77.53	58.43	59.27	58.85
	Line 1	33.20	35.83	34.52	7.53	7.70	7.62	30.03	27.80	28.92	81.50	90.57	86.03	62.40	66.47	64.43
	Ismalia 1	45.10	44.20	44.65	7.97	8.50	8.23	34.03	30.73	32.38	109.03	110.90	109.97	83.53	79.03	81.28
LSD 5%		1.13	0.86	0.66	0.37	0.28	0.26	1.96	1.60	1.44	4.82	6.68	3.13	5.31	2.77	3.57

Interaction		Yield traits			Pod and seed traits											
		Seed yield feddan^{-1}, Ardab			No. of seeds plant^{-1}			100-seed weight, g			100-pods weight			Shelling %		
		1st	2nd	Com.	1st	2nd	Com.	1st	2nd	Com.	1st	2nd	Com.	1st	2nd	Com.
Control	Line 8	12.30	12.63	12.47	29.80	24.27	27.03	74.30	90.03	82.17	149.40	176.33	162.87	49.37	53.63	51.50
	Line 1	14.30	13.27	13.78	33.10	29.83	31.47	82.20	92.57	87.38	166.30	185.63	175.97	50.10	58.77	54.43
	Ismailia 1	16.10	13.97	15.03	36.30	33.77	35.03	83.77	100.87	92.32	178.33	187.37	182.85	51.73	63.93	57.83
Calcium chloride	Line 8	16.10	13.97	15.03	36.30	33.77	35.03	83.43	100.87	92.15	176.40	184.00	180.20	51.73	63.93	57.83
	Line 1	16.57	13.97	15.27	37.03	33.77	35.40	83.77	100.87	92.32	189.70	197.47	193.58	51.73	63.93	57.83
	Ismailia 1	17.30	15.30	16.30	39.13	42.40	40.77	97.13	110.23	103.68	193.47	203.17	198.32	65.03	64.93	64.98
Calcium nitrate	Line 8	17.30	13.97	15.63	39.13	33.77	36.45	97.13	101.40	99.27	193.47	205.13	199.30	51.73	64.37	58.05
	Line 1	17.30	15.30	16.30	39.53	42.40	40.97	97.13	110.23	103.68	193.77	212.00	202.88	65.03	64.93	64.98
	Ismailia 1	19.43	20.57	20.00	41.27	43.43	42.35	117.00	124.37	120.68	204.43	223.97	214.20	65.37	70.83	68.10
Calcium sulfate	Line 8	20.07	20.57	20.32	41.27	43.43	42.35	117.00	124.37	120.68	200.47	205.40	202.93	65.37	70.83	68.10
	Line 1	21.93	22.47	22.20	63.87	52.20	58.03	117.00	124.37	120.68	204.43	223.97	214.20	75.67	74.73	75.20
	Ismailia 1	24.07	23.53	23.80	75.67	60.03	67.85	185.53	190.70	188.12	206.30	230.97	218.63	76.50	86.03	81.27
LSD 5%		0.93	1.70	0.96	4.94	N.S	4.10	7.68	7.71	7.07	6.55	4.41	4.17	1.45	N.S	2.77

Table 8: Correlation coefficient matrix among seed weight plant^{-1} and its related traits (combined data of over treatments and both seasons of 2016 and 2017)

	Stem length	No. of Branches plant^{-1}	No. of Pods plant^{-1}	100-pods weight	Pods Weight plant^{-1}	No. of seeds plant^{-1}	100-seed weight	Seed Weight plant^{-1}
Stem length	1.00	0.79**	0.93**	0.84**	0.98**	0.94**	0.98**	0.99**
No. of branches plant^{-1}		1.00	0.83**	0.93**	0.83**	0.75**	0.70**	0.78**
No. of pods plant^{-1}			1.00	0.91**	0.94**	0.96**	0.92**	0.95**
100-pods weight				1.00	0.87**	0.96**	0.95**	0.98**
Pods weight plant^{-1}					1.00	0.84**	0.78**	0.86**
No. of seeds plant^{-1}						1.00	0.93**	0.98**
100-seed weight							1.00	0.98**
Seed weight plant^{-1}								1.00

Table 9: The coefficient of determination (CD) and relative importance (RI) according to path analysis of seed weight and its related traits (combined data of over treatments and both seasons of 2016 and 2017)

Traits	CD	Contribution %	RI%
Direct effects			
No. of branches plant^{-1}, X_1	0.01	0.52	0.16
No. of pods plant^{-1}, X_2	0.17	17.24	5.28
100-pods weight, X_3	0.00	0.14	0.04
Pods weight plant^{-1}, X_4	0.07	6.57	2.01
No. of seeds plant^{-1}, X_5	1.15	115.21	35.26
Total(direct)	1.40	139.68	42.75
Indirect effects			
X_1 via X_2	-0.05	-4.97	1.52
X_1 via X_3	0.01	0.50	0.15
X_1 via X_4	0.03	3.07	0.94
X_1 via X_5	0.12	11.62	3.56
X_2 via X_3	-0.03	-2.82	0.86
X_2 via X_4	-0.20	-20.01	6.12
X_2 via X_5	-0.86	-85.57	26.19
X_3 via X_4	0.02	1.66	0.51
X_3 via X_5	0.08	7.69	2.35
X_4 via X_5	0.46	46.23	14.15
Indirect total (absolute)	1.84	184.15	56.36
Total (direct + indirect)	3.24	323.83	99.10
Residuals	0.03	2.93	0.90
Absolute total	3.27	326.76	100.00

Results showed that the most important relationships to peanut breeder were those between seed weight plant^{-1}and each of stem length (0.99**), No. of branches plant^{-1} (0.78**), No. of pods plant^{-1}(0.95**), 100-pods weight (0.98**), pods weight plant^{-1}(0.86**), No. of seeds plant^{-1} (0.98**) and 100-seed weight (0.98**).

It is evident that the selection for the previous traits would improve the productivity of peanut due to their positive and highly significant association with seed weight plant^{-1}.On the other hand, yield components appeared positive and highly significant associations among themselves.

Coefficient of determination and relative importance

Information obtained from correlation coefficients can be augmented by partitioning the correlation coefficients into direct and indirect effects for a given set of causal interrelationships.

In such situations, the correlation coefficients may be confounded with indirect effects due to common inherent in trait interrelationships. So, path coefficient analysis has proven useful in providing additional information that describes the casual relationships such as yield and its attributes. In the present investigation, the resultant variable was seed weight plant^{-1}, while the remaining traits represented the casual variables. The coefficient of determination (CD) and relative importance (RI %) for the yield attributes of peanut are listed in Table 9. The results revealed that the greatest parts of seed weight plant^{-1} variation were explained by the direct effect for No. of seeds plant^{-1} being 35.26%, followed by No. of pods plant^{-1}being 5.28% and pods weight plant^{-1} being 2.01 %. The considerable contribution of the three traits on peanut yield proves they may be used as selection criteria in peanut breeding program. However, the other characters recorded small or negligible direct effects upon seed weight plant^{1}. Regarding the relative importance of joint effects components, considerable parts of indirect effects were obtained by No. of pods plant^{-1} on seed weight plant^{-1} through its association with No. of seeds plant^{-1} being 26.19 % followed by pods weight plant^{-1} via No. of seeds plant^{-1} being 14.15%. Totally, the studied traits explained about 99.10% of seed weight plant^{-1} variation. Accordingly, the residual effect of other seed yield attributes was negligible (0.90) of the total seed weight plant^{-1} variation.

CONCLUSION

In view of the aforementioned results, it appears that foliar feeding with different calcium sources especially calcium sulfate improved the yield and its related traits of three peanut genotypes. The higher yield potential of peanut was achieved with spraying Ismailia 1 with calcium sulfate in combination with recommended dose of soil calcium application. The maximum benefit due to application of calcium fertilizer is not obtained in absence of adequate quantities of available calcium in the soil. It has been well established that most of calcium is absorbed through the leaves and absorption would be remarkably rapid and nearly complete. Thus, it could be recommended by sowing peanut cv. Ismailia 1 with foliar calcium sulfate spray of 3 kg feddan^{-1} in combination with recommended dose of soil calcium application. This study also indicated that the importance of selection for No. of seeds plant^{-1} and No. of pods plant^{-1}totheir direct and indirect impact on seed weight plant^{-1}.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

All authors equally in their efforts to conduct this work.

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