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Peanut Yield and Oil Response to Application Methods and Zinc Concentration

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ABSTRACT

From the field of Khabat Technical Institute- Erbil Polytechnic University the research was conducted in the summer season of 2021. It shows peanut yield and oil response to application methods and zinc concentration. A factorial experimental design was applied in a randomized complete block design (RBCD) with replications; the first factor represents seed treatment by four concentrations of Zinc (0, 1, 2 and 3 g Zn kg seed^{-1}) and second factor was a foliar spray application by four concentrations of Zinc (0, 2000, 4000 and 6000 Zn mg liter^{-1}). The combined effect of seed treatment by 1 g Zn kg seed^{-1} and 2000 mg liter^{-1} of zinc foliar spray application, produced the highest value of a number of pod plant^{-1}, pod and seed yield (kg ha^{-1}), oil and protein yield (kg ha^{-1}), but the seed treatment by 2 g Zn kg seed^{-1} and 4000 mg liter^{-1} of zinc foliar application surpassed in weight of 100 pod (g), weight of 100 seed, oil and protein percentage while 1 g Zn kg seed^{-1} and 4000 mg liter^{-1} of zinc obtained the heights branches of plant^{-1}. The interaction between seed treatment 1 g Zn kg seed^{-1} with 2000 mg liter^{-1} of zinc foliar application recorded the highest number of pod plant^{-1}, seed yield (kg ha^{-1}), oil percentage, oil and protein yield (kg ha^{-1}). The interaction treatment 2 g Zn kg seed^{-1} with 4000 mg liter^{-1} of zinc recorded the highest value in weight of 100 pods (g), weight of 100 seed, pods yield (kg ha^{-1}) and protein percentage.

استجابة الحاصل والزيت في فستق الحقل لطريقة المعاملة بالزنك وتركيزه

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الخلاصة

اجريت تجربة في حقل المعهد التقني خبات - جامعة تقني اربيل خلال الموسم الصيفي (2021) بهدف دراسة استجابة محصول فستق الحقل لطرق المعاملة وتاثيرها في الحاصل والزيت. طبقت تجربة عاملية بتصميم القطاعات الكاملة المعشاة و

بثلاث مكرارات مثل العامل الاول معاملة البذور بأربع تراكيز من الزنك (0 و 1 و 2 و 4 غم من الزنك لكل 1 كغم بذرة-1) والعامل الثاني تمثل باربع تراكز رشاً على الاوراق (0 و 2000 و 4000 و 6000 الزنك لكل ملغم لتر-1). أظهرت النتائج ان معاملة البذور بمقدار 1 غم زنك كغم بذرة -1 و 2000 ملغم لتر-1 من معاملة الزنك بالرش على الأوراق اعطت أعلى قيمة لعدد القرنات نبات-1، حاصل القرنات (كغم هـ-1)، حاصل البذور (كغم هـ- 1)، حاصل الزيت (كغم هـ- 1) و حاصل البروتين (كغم هـ- 1)، ولكن عند معاملة البذور بمقدار 2 غم من الزنك كغم بذرة-1 و 4000 ملغم لتر-1 من معاملة الرش على الاوراق من الزنك تفوقت على وزن 100 قرنات (غم) و وزن 100 بذرة و نسبة الزيت % و نسبة البروتين % . اما عند تداخل العاملين سجلت معاملة البذور 1 غم من الزنك كغم بذرة-1 مع 2000 ملغم لتر-1 من معاملة الرش على الاوراق أعلى قيمة لعدد القرنات نبات-1، حاصل البذور (كغم هـ- 1) ، نسبة الزيت %، حاصل الزيت (كغم هـ- 1) وحاصل البروتين (كغم هـ- 1). من ناحية أخرى سجلت المعاملة التداخلية 2 غم من الزنك كغم بذرة-1 مع 4000 ملغم لتر-1 من الزنك أعلى قيمة في الوزن 100 قرنة (غم) و وزن 100 بذرة وحاصل القرنات (كغم هـ- 1) و نسبة البروتين.

الكلمات المفتاحية: فستق الحقل, الحاصل, الزيت,نقع البذور و رش الأوراق بالزنك.

INTRODUCTION

Peanut (*Arachis hypogaea* L.) is a crucial oil seed crop and food grain, It is cultivated in more than 100 countries in the world and is produced in countries that lie below the tropical and subtropical line (Westphal et al., 1985). Oil percentage in peanut seeds ranges from (35-50 %) and the amount rises to 55% in some of new cultivars (Abbas, 2001). The high-energy, protein percentage and minerals content make it an excellent nutritious source at a comparatively low price. The resulting seed cakes are regarded as high-protein animal feed. It is frequently used in human nutrition and comprises roughly 50% oil, 25% to 30% protein, 20% carbs, 5% fiber, and ash. Furthermore, Vitamins E, K, and B are all present in peanuts in significant amounts. It is the most abundant source of thiamine and niacin in plants, which are both lacking in cereals. (Fageria et al., 1997). One of the elements necessary for plant growth is zinc, and the concentration of zinc in plants affects various enzymes which are involved in the biosynthesis of growth, such as auxin, which is necessary for both cell division and plant growth (Auld, 2001). Also Singh (2007) reported that deficiency of Zn was affecting the production of peanuts, negatively influencing the yield components and quality.

A response of plant to micronutrient levels applied through different methods is varied. Hugar and Kurdikeri (2000) concluded that applied Zn through seed treatment before sowing at 2 g/ah followed by foliar spray at 0.5 % during flowing for better growth performance and increase yield. Application seed treatment by zinc (1 g zinc sulphate kg/seed) recorded the highest yield and oil yields kg ha^{-1} and protein content% (Darwish et al., 2002). Nutrient seed preparation is an economically efficient method because it applied low concentrations of micronutrients and it also facilitates the process of germination and seedlings for the growth of crops (Singh, 2003). According to several researchers, foliar zinc spray could improve peanut growth, production, and seed quality by correcting zinc deficiency. Ali and Mowafy (2003) explained that peanut yield and seed quality slightly improved when applied zinc foliar spray by (2%). Habbasha et al., (2014) observed that Zn use by the foliar spray at flowering stages caused to increase in the yield components, oil yield, and protein percentage.

The main objective of this study is evaluated of peanut yield component and seed quality by different application methods; seed treatment and foliar spray application of zinc concentration.

Materials and Methods

The research was applied in the field of Khabat Technical Institute-Erbil Polytechnic University, Latitude 36° 4' N and Longitude 44°2' E, with an elevation of 415 meters above sea level and annual rainfall between (250-600 mm), from the summer season of 2021 to evaluate peanut yield components and seed quality using different application methods of zinc; seed treatment and foliar spray application. Randomized complete block design (RCBD) as an experimental design was applied in three replicates. Two methods of application; seed treatment, (four levels of Zinc: 0, 1, 2 and 3 g) amount of zing for a kg of seed and foliar application by four concentrations of Zinc (0, 2000, 4000 and 6000 Zn mg liter^{-1}) were used. From different locations of the field, samples were taken after plowing at depths (0-30 cm) table (2).

The field was plowed for preparing a good seedbed and also to controlling weeds prior of planting, the land manually was divided into plots, and experimental units contained 16 plots in each replicate (2 m×2 m). At the planting date, phosphate fertilizer in the form of triple super phosphate (46% P2O5) was applied at a rate of 80 kg ha^{-1}, and nitrogen fertilizer in the form of urea (46%N) at a rate of 100 kg N ha^{-1}. (AL-Dulaimy 2000). The Agricultural Research Center in Erbil, Iraq, provided the Soodary genotype of peanut seeds. The seeds were treated and soaked in the solution according to zinc concentrations (kg seeds^{-1}) for 12 hours before planting and then planted manually from 1 May at row spacing of 50 cm and 20 cm plant spacing. Two seeds were planted in each hill at a depth of 3 cm, and then seedlings were thinned to (10 plant m^{-1}). Plants were sprayed with zinc after 30 days of both sowing and flowering. Five plants were selected at random from plots in the middle lines to study: the number of primary branches plant^{-1}, number of pod plant^{-1}, number of seeds pod^{-1}, the weight of 100 pods (g), the weight of 100 seeds (g), pod yield (kg ha^{-1}), seed yield (kg ha^{-1}), oil content%, oil yield (kg ha^{-1}), protein content% and protein yield (kg ha^{-1}). Statistical Analysis System (SAS) were used for the analysis of variance (SAS Institute, 2005). To compare all mean traits, Duncan's DMRT multiple range test was used at the 5% level, simple regression of some studied traits was calculated (Al-Rawi, 1984).

Table (1): Meteorological data from the summer season of (2021) for the Khabat field station

Parameter Year 2021	**Air Temperature (°C)**			**Rainfalls for every month (mm)**	**Humidity R.H%**
	Maximum	**Minimum**	**Average**		
May 2021	38.3	17.1	27.7	1.0	47.3
Jun 2021	41.3	21.7	31.5	---	42.8
July 2021	46.4	26.8	36.6	---	45.3
August 2021	45.6	25.9	35.6	---	45.1
September 2021	39.4	19.5	29.5	---	49.3
October 2021	32.6	15.5	24.0	4.2	50.0
November 2021	24.8	8.7	16.8	8.2	67.5

Table (2): Properties of some physical and chemical at a depth (30 cm) of the soil.

Depth cm	**PSD %**			**Soil Texture**	**pH**	**Ec ds/m**	**O.M %**	**(N) %**	**Available (P)**	**K^{+}**	**Ca^{+2}**	**Mg^{+2}**	**Zn**	**Mn**
	Sand	**Silt**	**Clay**											
	g kg^{-1} soil					**dS.m^{-1}**	**%**		**mg.g^{-1}**	**Mmolic.L^{-1}**			**%**	
0-30	6	50	44	Silty clay	7.5	1.3	1.1	0.27	3.76	0.22	6.57	3.98	0.0030	0.0025

RESULTS AND DISCUSSION.

The effect of seed treatment and foliar zinc concentrations is shown in table 3. The maximum number of branch recorded in seed treatment by 1 g Zn kg seed^{-1} (12.16) whereas the minimum was for 3 g Zn kg seed^{-1} (8.66). However, the different concentration of zinc foliar application, 4000 mg liter^{-1} obtained a significantly higher number of branches (11.33). The superior interaction was (15.66) for seed treatment 1 g Zn kg seed^{-1} with foliar zinc concentrations 4000 mg liter^{-1}, but the least value was recorded (6.66) for seed treatment 2 g Zn kg seed^{-1} with foliar zinc concentrations 0 mg liter^{-1} (table 4).

Table (3) displayed a wide variation between treatments; the greatest number of pods in plant was when the seed treatment by 1 g Zn kg seed^{-1} (115.08), while the lowest number was recorded at 0 g Zn kg seed^{-1} which was (87.58). This result is similar with Khan et al., (2017) noticed that number of pods in plant was increased with seed treatment by 1% Zn. The foliar spray of Zn affected significantly the greatest number (121.50) was recorded from 2000 mg liter^{-1} of Zn. While the minimum values (78.66) were obtained from treatments 6000 mg liter^{-1} of Zn. also El Habasha et al., (2014) stated that 1000 mg liter^{-1} of Zinc foliar application increased number of pods in plant. From interaction seed treatment with zinc foliar application also had significant effects on these traits; the greatest value (148.00) was due to the interaction 1 g Zn kg seed^{-1} with 2000 mg liter^{-1} of Zn, and the lowest (72.66) was given from interaction 0 g Zn kg seed^{-1} with 6000 mg liter^{-1} of Zn. there was a directly proportional relationship according to the following equation ($\hat{Y}$= 11.75X 12.375) between the number of branches plant^{-1} and the pods plant^{-1} figure 1A.

Data in table (3) also shows that the largest number of seeds from the pod was observed in seed treatment at 2 g Zn kg seed^{-1} which was (2.01), whereas the lowest was collected at 1 g Zn kg seed^{-1} which was (1.90). While the foliar spray application of zinc concentration was non-significant on number of seeds from the pod. Considering the interaction between seed treatment with zinc foliar application, the highest was (2.06) for 2 g Zn kg seed^{-1} with 6000 mg liter^{-1} of Zn, while the lowest value was observed from 0 g Zn kg seed^{-1} with 6000 mg liter^{-1} of Zn (1.73) table 4.

Table (3) shows the highest 100 pod weight for seed treatment by used 2 g Zn kg seed^{-1} which was (197.19 g), but the lowest weight of 100-pod (g) was gave at 0 g Zn kg seed^{-1} which was (157.00 g). The heights value in foliar application of zinc concentration was at 4000 mg liter^{-1} of Zn (174.90 g) and the minimum was at 0 mg liter^{-1} of Zn (155.70 g). This result is similar with El Habasha et al., (2014) noticed that foliar spray of Zinc was highly significantly weight of 100-pod when applied 1000 mg liter^{-1} of zinc which recorded (185.81) g. From table (4) shows seed treatment at 2 g Zn kg seed^{-1} with zinc foliar application 4000 mg liter^{-1} recorded the highest weight (192.14 g), but the lowest was (152.40 g) for 0 g Zn kg seed^{-1} at 0 mg liter^{-1} of zinc foliar application.

Table 3: Effect of application methods and zinc concentration on peanut yield and yield components.

seed treatment g Zn (kg seed^{-1})	**No. of branch plant^{-1}**	**No. of pod plant^{-1}**	**No. of seed pod^{-1}**	**100 Pod Weight (g)**	**100 seed Weight (g)**	**Pod yield (kg ha^{-1})**	**Seed yield (kg ha^{-1})**
Zn 0	10.33 ab	87.58 b	1.99 ab	157.00 d	47.33 c	4019.63 c	2871.16 c
Zn 1	12.16 a	115.08 a	1.90 b	168.57 b	55.13 b	5277.21 a	4001.58 a
Zn 2	8.66 b	114.58 a	2.01 a	197.19 a	58.87 a	4717.98 b	3149.75 b
Zn 3	9.25 ab	99.83 b	2.00 ab	162.69 c	47.78 c	4160.58 c	3245.75 b
Foliar application of Zinc mg liter^{-1}							
Zn 0	7.83 b	107.66 ab	1.91 a	155.70 d	51.22 c	4899.82 a	3470.16 b
Zn 2000	10.25 ab	121.50 a	2.00 a	170.94 b	56.04 b	4953.03 a	3877.20 a
Zn 4000	11.33 a	109.25 ab	1.98 a	174.90 a	60.33 a	4798.75 a	3582.50 b
Zn 6000	11.00 a	78.66 b	2.00 a	165.92 c	41.51 d	3523.80 b	2338.37 c

Similar letters of means are not significantly difference

Table (3) showed the height significance between seed treatment, zinc foliar application and their interactions. It was found that the seed treatment by 2 g Zn kg seed^{-1} recorded the heaviest weight of 100-seed (58.87 g), while the seed treatment by 0 g Zn kg seed^{-1} recorded the lowest 100-

seed weight (47.33 g). Also Khan et al., (2017) concluded that the heaviest weight of 100 seeds was recorded (53.9 g) from seed treatment by 1% Zn before planting. The results showed that 4000 mg liter^{-1} of Zn concentration was surpassed in 100-seed weight (60.33 g), while 6000 mg liter^{-1} of Zn foliar application gave the lowest (41.51 g). The interaction between seed treatment with zinc foliar significantly affected on this trait, it was found that 2 g Zn kg seed^{-1} with 4000 mg liter^{-1} of zinc recorded the highest weight of 100-seed (74.52%), compared with other interactions.

The seeds treated with 1 g of Zn kg seed^{-1} produced a greater amount of pod yield (5277.21 kg ha^{-1}), but the lowest was at 0 g Zn kg seed^{-1} (4019.63 kg ha^{-1}). Regarding zinc foliar application, the highest value was obtained at 2000 mg liter^{-1} of zinc (4953.03 kg ha^{-1}) and the lowest was at 6000 mg liter^{-1} of zinc (3523.80 kg ha^{-1}). The variations yield of pods, confirm that the interaction among seed treatment and concentrations of zinc foliar spray are significant. The superior value was from seed treatment by 2 g Zn kg seed^{-1} with zinc foliar application at 4000 mg liter^{-1} (6611.60 kg ha^{-1}), whereas the minimum was for 3 g Zn kg seed^{-1} at 6000 mg liter^{-1} (3146.86 kg ha^{-1}). These results are similar to those of Esmail Pour, et al., (2010) whom showed that the foliar spray with zinc sulphate increased pod yield of plants. The table (3) showed the highest seed yield performed from used seed treatment by 1 g Zn kg seed^{-1} (4001.58 kg ha^{-1}), while the lowest was at 0 g Zn kg seed^{-1} (2871.16 kg ha^{-1}). The highest value was also for zinc foliar application at 2000 mg liter^{-1} (3877.20 kg ha^{-1}) while the lowest was (2338.37 kg ha^{-1}) at 6000 mg liter^{-1} of foliar zinc concentration, this variation is due to when planting peanut by seed treatment 1 g Zn kg seed^{-1} and foliar application of zinc at 2000 mg liter^{-1} leads to increase no. of branches plant^{-1}, no. of pod plant^{-1} and pod yield kg ha^{-1} and consequently resulted to increase of yield. The variations in yields confirmed that the interaction between seed treatment and foliar zinc concentration is different. The optimum value was at seed treatment by 1 g Zn kg seed^{-1} with zinc foliar application at 2000 mg liter^{-1} (5197.33kg ha^{-1}), whereas the minimum was at 0 g Zn kg seed^{-1} with Zn 6000 mg liter^{-1} (2267.66 kg ha^{-1}). Ali and Mowafy (2003) reported that peanut yield and seed quality slightly improved when applied zinc foliar spray by (2%). Yield loss causes Zinc deficiency of up to 40% in peanut Radhika and Meena (2021). Figures 1B and C show that there was a clear relationship between seed yield and the number of pods per plant, according to the following equations ($\hat{Y}$= 12.289X + 2913.2).

Table 4: Effect of Interaction between application method and concentration of Zinc on yield and yield components of peanut

Seed treatment g Zn (kg seed^{-1})	Foliar application of Zinc mg liter^{-1}	No. of branch plant^{-1}	No. of pod plant^{-1}	No. of seed pod^{-1}	100 Pod Weight (g)	100 seed Weight (g)	Pod yield (kg ha^{-1})	Seed yield (kg ha^{-1})
Zn 0	Zn 0	7.33 b	92.66 b	2.00 a	152.40 e	41.48 g	3625.36 cde	2508.33 ij
	Zn 2000	12.00 ab	97.66 b	2.00 a	167.37 d	56.24 d	5731.56 b	4236.83 c
	Zn 4000	13.33 ab	87.00 b	2.00 a	162.44 d	53.43 e	3312.00 e	2905.16 gh
	Zn 6000	8.66 b	72.66 b	1.73 b	154.81 e	38.33 h	3574.73 de	2267.66 j
Zn 1	Zn 0	9.00 b	112.33 ab	1.96 ab	168.21 cd	55.37 d	5582.90 ab	3773.50 d
	Zn 2000	11.33 ab	148.00 a	2.00 a	161.07 d	51.43 e	6476.26 a	5197.33 a
	Zn 4000	15.66 a	116.00 ab	1.93 ab	182.62 b	62.16 b	5435.53 ab	4739.66 b
	Zn 6000	12.66 ab	84.00 b	1.93 ab	162.44 d	51.57 e	3614.16 cde	2303.83 ij
Zn 2	Zn 0	6.66 b	116.66 ab	1.96 ab	178.66 b	59.80 c	5128.70 b	3520.50 ef
	Zn 2000	9.33 ab	130.33 ab	2.00 a	179.51 b	59.67 c	3537.30 de	3169.50 fg
	Zn 4000	11.00 ab	138.66 ab	2.03 a	192.14 a	74.52 a	6611.60 a	3627.33 de
	Zn 6000	7.66 a	73.00 b	2.06 a	166.44 d	41.47 g	3594.33 de	2281.66 ij
Zn 3	Zn 0	8.33 b	109.00 ab	1.96 ab	164.40 d	48.24 f	5262.33 b	4282.83 c
	Zn 2000	8.33 b	110.00 ab	2.03 a	175.81 bc	56.83 d	4067.00 c	3286.66 ef
	Zn 4000	8.33 b	95.33 b	1.96 ab	162.40 d	51.38 e	4001.00 cd	3283.66 ef
	Zn 6000	12.00 ab	85.00 b	2.03 a	148.14 e	34.67 i	3146.86 e	2676.33 hi

Similar letters of means are not significantly difference

From (Table, 5) showed highly significant differences between seed treatment, zinc foliar application and their interactions. It was found that seed treatment with 2 g Zn kg seed^{-1} recorded the highest oil content (44.61 %), while the 3 g Zn kg seed^{-1} recorded the lowest oil content (39.60 %). The results showed that 4000 mg liter^{-1} of Zn foliar application was surpassed in oil percentage (45.32 %), while 6000 mg liter^{-1} of Zn gave the lowest oil percentage (40.08 %), The interaction between seed treatment with zinc foliar significantly affected on this trait table (6), it was found that 1 g Zn kg seed^{-1} with 2000 mg liter^{-1} of Zn concentration recorded the highest oil percentage (47.55%), compared with other interactions**.** Saha et al., (2015) reported that maximum oil percentage affected by foliar spray of zinc at 10 kg ha^{-1}.

Table (5) displayed that the highest amount was recorded at seed treatment by 1 g Zn kg seed^{-1} which was (1771.56 kg ha^{-1}), while the lowest level of seed treatment was at 0 g Zn kg seed^{-1} (1276.32 kg ha^{-1}), also the maximum was at 2000 mg liter^{-1} of Zn foliar application that was (1648.20 kg ha^{-1}, but the minimum rate recorded at 6000 mg liter^{-1} of zinc concentration (936.74 kg ha^{-1}). Seed treatment with foliar spray of zinc gave the highest yield of oil at seed treatment by 1 g Zn kg seed^{-1} with 2000 mg liter^{-1} and of Zn foliar application (2302.49 kg ha^{-1}). Saren et al., (2007) studied an increased oil yield significantly as affected by spray foliar of zinc at 20 kg ha^{-1}. Figure 1 (E) showed a directly proportional relationship as in the following equation ($\hat{Y}$= 68.75X + 1619.3) between seed yield, oil percentage, and oil yield, means an increase of one percentage in oil will resulted increase oil yield by (68.75 kg ha^{-1}). The heights protein percentage was the recorded at 2 g Zn kg seed^{-1} of seed treatment which was (25.31%) and the minimum by 0 g Zn kg seed^{-1} that was (23.49 %), The results obtained correspond with Nadaf et al., (2011) observation that peanut crops' protein content increased as a result of the spraying of zinc sulphate at a rate of 20 kg ha-1.. Foliar application of zinc at 4000 mg liter^{-1} recorded the highest content of protein (24.56 %), whereas the interaction among seed treatment and zinc foliar application the maximum rate also of seed treatment at 2 g Zn kg seed^{-1} with 4000 mg liter^{-1} of zinc concentration which was (27.73 %) and the minimum was at 3 g Zn kg seed^{-1} with 4000 mg liter^{-1} of zinc that was (22.52 %) table (6). According to Bairagi et al., (2007), a height protein percentage was obtained when zinc was applied at a rate of 10 kg ha^{-1}.

Table 5: Effect of application methods and zinc concentration on oil and protein percentage and its yield of peanut

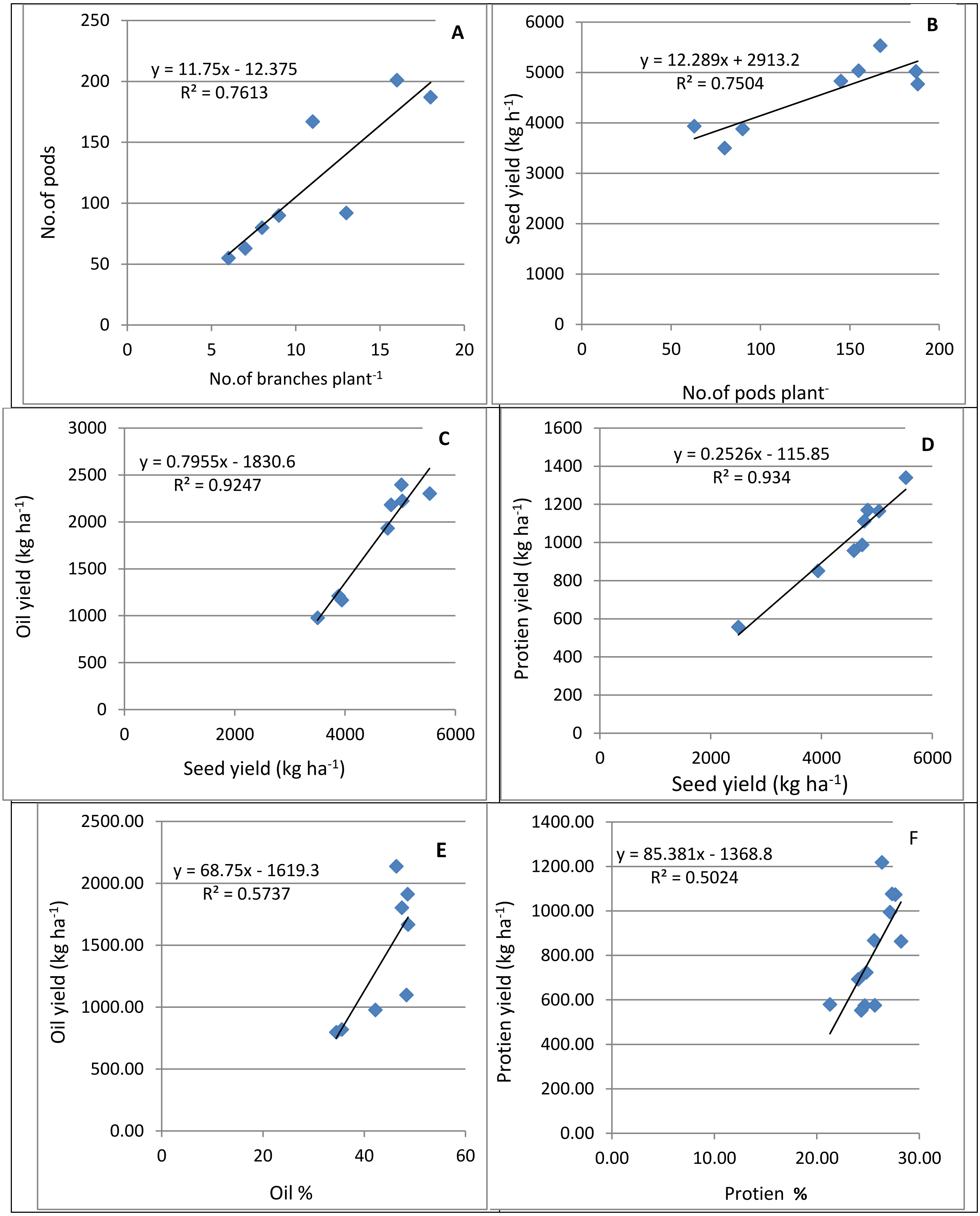
Seed treatment g Zn (kg seed^{-1})	Oil %	Oil yield (kg ha^{-1})	Protein %	Protein yield (kg ha^{-1})
Zn 0	41.13 c	1276.32 b	23.49 c	694.71 c
Zn 1	43.30 b	1771.56 a	24.32 b	940.76 a
Zn 2	44.61 a	1307.17 b	25.31 a	799.54 b
Zn 3	39.60 d	1278.17 b	24.06 b	787.66 b
Foliar application of Zinc mg liter^{-1}				
Zn 0	41.17 c	1420.91 b	24.36 ab	859.82 b
Zn 2000	42.08 b	1648.20 a	23.95 b	925.97 a
Zn 4000	45.32 a	1627.37 a	24.56 a	869.11 b
Zn 6000	40.08 d	936.74 c	24.31 ab	567.78 c

The highest rate (940.76 kg ha^{-1}) was recorded at seed treatment by 1 g Zn kg seed^{-1}, while the minimum rate (694.71 kg ha^{-1}) was observed at 0 g Zn kg seed^{-1}. The foliar application of zinc concentration at 2000 mg liter^{-1} recorded the highest yield of protein which was (925.97 kg ha^{-1}), but the lowest was in 6000 mg liter^{-1} of zinc concentration (567.78 kg ha^{-1}). The result agrees with the detection of Gobarah et al., (2006) pointed out that foliar spray by 1 g liter^{-1} of zinc increased protein yield of plants. The interaction between seed treatment with Zn concentrated significantly affected Protein yield, it was found at 1 g Zn kg seed^{-1} with 2000 mg liter^{-1} of Zn gave the highest value (1225.44 kg ha^{-1}), compared with 0 g Zn kg seed^{-1} with 0 mg liter^{-1} of Zn which recorded the lowest value was (528.18 kg ha^{-1}) for this trait.

Table 6: Effect of Interaction between application method and concentration of Zinc on oil and protein percentage and its yield of peanut

Protein yield (kg ha^{-1})	Protein percentage	Oil yield (kg ha^{-1})	Oil percentage	Foliar application of Zinc mg liter^{-1}	Seed treatment g Zn (kg seed^{-1})
Zn 0	Zn 0	528.18 j	23.11 fg	972.40 ijk	42.22 ef
	Zn 2000	1001.15 cd	23.63 defg	1842.57 b	43.48 ef
	Zn 4000	655.18 hi	24.49 cde	1217.21 fgh	45.47 cd
	Zn 6000	589.93 ij	26.03 b	1073.11 ghi	47.29 ab
Zn 1	Zn 0	932.69 de	24.70 cd	1794.39 b	44.33 de
	Zn 2000	1225.44 a	23.55 defg	2302.49 a	47.55 a
	Zn 4000	1073.73 bc	22.72 g	2176.62 a	45.92 bc
	Zn 6000	532.95 j	23.00 fg	865.09 jk	35.41 l
Zn 2	Zn 0	847.26 ef	24.06 cdef	1346.46 de	38.25 ij
	Zn 2000	778.67 fg	24.57 cde	1303.23 def	41.12 gh
	Zn 4000	1004.60 cd	27.73 a	1713.91 bc	47.25 ab
	Zn 6000	567.63 ij	24.83 c	812.73 k	37.92 jk
Zn 3	Zn 0	1126.73 b	26.36 b	1570.41 c	36.66 l
	Zn 2000	698.60 gh	24.05 cdef	1144.50 fgh	39.39 ij
	Zn 4000	739.96 gh	22.52 g	1401.73 d	42.66 fg
	Zn 6000	585.36 ij	23.33 efg	996.03 hij	49.70 hi

Similar letters of means are not significantly difference



CONCLUSION

The results of present study show that seed treatment by 1 g Zn kg seed^{-1} and foliar application by 2000 mg liter^{-1} of zinc concentration recorded highest number of pod per plant, pod yield (kg ha^{-1}), seed yield (kg ha^{-1}), oil yield (kg ha^{-1}) and protein yield (kg ha^{-1}), while 100 pod weight (g), 100 seed weight (g), oil percentage and protein percentage, recorded on application of seed treatment by 2 g Zn kg seed^{-1} and foliar of zinc at 4000 mg liter^{-1}. The interaction between seed treatment 1 g Zn kg seed^{-1} with 2000 mg liter^{-1} of zinc foliar application recorded the highest value of number of pod per plant, seed yield (kg ha^{-1}), oil percentage, oil yield (kg ha^{-1}) and protein yield (kg ha^{-1}). Regarding the interaction of seed treatment by 2 g Zn kg seed^{-1} with 4000 mg liter^{-1} of zinc recorded the highest value in weight of 100 pods (g), weight of 100 seed, pods yield (kg ha^{-1}) and protein percentage.

CONFLICT OF INTEREST

The authors declare no conflicts of interest associated with this manuscript.

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