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Responses of *Arachis hypogaea* (Pea nut) to Salinity Stress

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ABSTRACT. The effect of different salinization levels (0.0, 1000, 3000, 5000 and 7000 ppm) which were made of a mixture of Nacl and $CaCl_2$ (1:1 w/w) on seed germination of pea nut was studied. Also, the changes in growth, pigment content and concentration of some mineral elements (Na, N, P, K, Ca, Mg) have been studied for pea nut plants grown in sand cultures at the same levels of salinization.

Germination of pea nut seeds was not greatly affected by all salinization levels used. The pigment contents of the leaves increased with the rise of salinization level. The dry weight yield and the concentration of most of the tested nutrient elements showed a non-significant variation with the rise of salinization level up to 5000 ppm, even though a slight decrease in the fresh weight was noticed at this level.

Introduction

Although saline soils occur in humid regions in areas affected by sea water, the most extensive occurrence is in arid and semi arid regions, where rainfall is not sufficient to transport salts away from the plant root zone. In such saline regions, cultivation of crop plants can be mainly achieved either after washing of excess salts by repeated flooding with fresh water or by introducing plants adopted to such saline conditions. Since sufficient amounts of fresh water are not always available, the second alternative seems to be more applicable. The plant adaptation to salinity should be tested from the beginning, that is from seed germination. The germinability of seeds under salinity conditions was recorded to be sometimes suppressed under salinity conditions. Extensive studies have been made concerning the effect of water stress on seed germination using different crop species and different osmotic substances; Darra *et*

al.[1], Hadas[2], Heikal *et al.*[3] and Khan and Naqvi[4]. Generally, it was recorded that salinity stress may slow down the rate of germination or may inhibit it completely; Heikal *et al.*[3] and Heikal and Shaddad[5].

During the vegetative growth, a considerable number of works were done to investigate the effects of salinity upon growth of plants. Morphologically, the most typical symptoms of saline injury to a plant is a stunted growth; Nieman[6]. A reduction in growth was also recorded by some authors; Ahmed *et al.*[7], Heikal *et al.*[8] and Ralph *et al.*[9].

The different pigment fractions and consequently the total pigments have been determined in various plants in relation to salt stress. It has been recorded that salinization exerted a general reduction in the contents of the photosynthetic pigments; Shimose[10], Heikal[11], Ahmed *et al.*[7] and El-Tayeb[12]. In some other cases, the contents of chlorophylls and carotenoids were consequently higher in salinized plants than in control plants; Dostanova[13]. Also, attention has been given to the problem of salinity as one of the major external factors which affect mineral metabolism. A number of investigators; Greenway[14], Shimose[15], Lashin and Atanasiu[16] and Heikal[17] demonstrated that nutrient uptake by certain plant species is curtailed by salinization. On the other hand, under certain experimental conditions, salinization results in promotion rather than an inhibition of nutrient uptake; Shimose[18].

The aim of the present investigation is to study the effects of different concentrations of solutions on germination, growth, pigment and mineral content of pea nut as oil producing plant.

Material and Methods

Germination Experiments

The germination experiments on the seed of *A. hypogaea* were performed as described by Maftoun and Sepaskhah[19] and continued for one week. The following salinization levels were used: 0.0 (control), 1000, 3000, 5000 and 7000 ppm salinity which were made of a mixture of NaCl and $CaCl_2$ (1:1 w/w) under room temperature (20°C day and 19°C night). Twenty seeds of *A. hypogaea* were placed on absorbent pads in petri dishes to which 30 ml of the experimental solution was added (3 petri dishes in each treatment). Seeds were considered to be germinated after the radical emerged from the testa.

Culture Technique

Seeds of pea nut were sown in perforated plastic pots, each containing two kgs of soil, composed of mixed sieved acid, washed sand and peatmoss (3:1 by volume). The pots were irrigated with fresh water till complete germination and seedling emergence. The pots were divided into five groups of five pots each. Two seedlings per pot were left to grow in green house at about 28°C and at a soil water potential near field capacity, then watered with ½ strength Hoagland nutrient solution containing various concentrations of NaCl and $CaCl_2$ (1:1 w/w) which is equivalent to the

salinization levels of 0, 1000, 3000, 5000 and 7000 ppm. Every two days, each group was irrigated with the respective saline solution. In order to prevent accumulation of salt, the soil in each pot was leached every 10 days with fresh water.

Determination of Photosynthetic Pigments

At the end of the experimental period (8 weeks), the photosynthetic pigments (chlorophyll a, chlorophyll b, and carotenoids) were determined using the spectrophotometric method recommended by Metzner *et al.*[20].

Growth Parameters

a) *Fresh Weight:* At the end of the experimental period, fresh shoots and roots from plants grown in each pot were weighed to determine the fresh weights.

b) *Dry Weight:* The fresh shoots and roots were then dried in an aerated oven at 70°C during which successive weighing was carried out until constant dry weight was reached.

Mineral Ions Determination

The dry samples were ground into a fine powder and assayed for mineral ion determinations using the wet digestion method; Humphries[21]. The flame photometer absorption method was used for Na, K, Ca and Mg determinations using an atomic absorption flame photometer to the type Shimadzu Aa-670/G U-4. Phosphorus was determined colorimetrically using the phosphomolybdate method; Woods and Melon[22]. Total nitrogen was also determined colorimetrically by the method adopted by Delory[23] using Nessler reagent.

In every case, at least three replicates were used and the data were statistically analyzed to calculate the least significant difference.

Results and Discussion

From Table 1 it can be noticed that the highest level of salinization (5000 & 7000 ppm) induced a significant decrease in the germination rate of pea nut seeds at the first day, in the second day, 7000 ppm caused a slight difference. This reduction is in agreement with the results obtained by Poljakoff-Mayber and Gale[24] and Heikal and Shaddad[5]. The other levels of salinization had a non-significant effect on the rate and final germination of seeds. This means that seed germination of pea nut was not affected by the relatively low and moderate salinization levels used.

According to the effect of salinity on pigment content, it can be observed that the high levels of salinization (5000 and 7000 ppm) induced a significant increase in the contents of pigment fractions and consequently of the total pigment content as compared with control plants (Table 2). The total pigment content of pea nut exhibited a significant increase at the level 3000 ppm. Whereas the other levels of salinization showed a non-significant effect on the pigment contents of pea nut leaves. Similar findings were also obtained by Dostanova[13] and Ahmed *et al.*[25].

TABLE 1. Effect of different salinization levels on the average germination of pea nut seeds.

Salinization level (ppm)	Germination (%)		
	First day	Second day	Third day
Control	40	100	100
1000	36	100	100
3000	32	100	100
5000	14*	100	100
7000	8*	90*	100
L.S.D. at 5%	12.41	4.14	0.0

*Significant differences as compared with control.

TABLE 2. Effect of saline irrigation on pigment content (mg/g dry weight) of pea nut leaves.

Salinization level (ppm)	Chl. a	Chl. b	Carot.	Total pigment
Control	4.03	2.88	2.33	9.24
1000	4.62	2.89	2.63	10.14
3000	4.62	3.07	2.93	10.62*
5000	5.80*	3.85*	3.14*	12.79*
7000	5.48*	3.86*	2.92	12.26*
L.S.D. at 5%	0.77	0.53	0.68	1.35

*Significant differences as compared with control.

Fresh and dry weights of pea nut plants treated with different salinity levels are given in Table 3. The results show that the salinization levels 1000 and 3000 ppm induced a non-significant reduction in the fresh and dry weights of shoots and roots as well as of the whole plant body. On the other hand, the level 5000 ppm induced a significant reduction in the fresh weight of shoot and whole plant body, whereas the level 7000 ppm induced a significant reduction in fresh and dry weights of shoots and roots as well as of the whole plant body as compared with control plants. This reduction in growth parameters (fresh and dry weights) which was pronounced with increasing salinization levels was observed by Hutton[26], Heikal[27], Shaddad and Heikal[28], Nerson and Paris[29] and Shaddad *et al.*[30] working with other plants.

The influence of the various salinity treatments on the element contents of the shoots and roots of pea nut are shown in Tables 4 and 5. Considerable differences in the content of mineral elements in shoots and roots of pea nut were induced by the different salinity levels. With increased salinity levels, the concentrations of Na and Ca in both shoots and roots were greatly increased (Tables 4 and 5). The increase in sodium content is in agreement with the results obtained by Morani and Fortini[31] working with oat, Heikal[17] working with some agricultural plants, and Heikal[32] working with some oil producing plants. The extent of sodium accumulation with

saline solutions varied among shoots and roots, the highest was estimated in the roots. In accordance with this, Jacoby[33] reported that in many glycophytes, most of sodium being retained in the roots.

TABLE 3. Effect of saline irrigation on fresh and dry weight yields (g/plant) of pea nut.

Salinization level (ppm)	Fresh weight			Dry weight		
	Root	Shoot	Total	Root	Shoot	Total
Control	3.04	12.20	15.24	0.12	1.60	1.72
1000	2.99	11.44	14.43	0.11	1.58	1.69
3000	3.04	11.49	14.53	0.11	1.63	1.74
5000	2.87	10.10*	12.97	0.10	1.37	1.47
7000	2.48	8.95*	11.43*	0.09*	1.21*	1.30*
L.S.D. at 5%	0.80	1.79	2.46	0.03	0.25	0.27

*Significant differences as compared with contr

TABLE 4. Effect of saline irrigation on the mineral contents of some of the shoot systems of pea nut

Salinization level (ppm)	Na	N	P	K	Ca	Mg
Control	3.33	24.20	5.96	22.53	14.15	4.69
1000	4.59	23.64	5.71	23.50	19.26*	4.18*
3000	4.67*	24.01	5.17	22.28	22.33*	3.95*
5000	5.04*	23.54	5.02*	22.36	23.55*	3.85*
7000	5.62*	19.97*	4.13*	18.66*	24.36*	3.34*
L.S.D. at 5%	1.30	2.24	0.80	3.40	2.72	0.58

*Significant differences as compared with the control.

TABLE 5. Effect of saline irrigation on contents of some mineral elements in the root system of pea nut

Salinization level (ppm)	Na	N	P	K	Ca	Mg
Control	10.59	18.16	6.48	12.71	4.07	7.19
1000	18.31*	17.59	5.78	12.47	4.66*	6.32*
3000	18.65*	17.64	5.42*	12.67	5.39*	6.28*
5000	19.48*	16.93	5.34*	12.64	5.59*	5.82*
7000	20.17*	14.70*	5.02*	10.42*	5.62*	5.29*
L.S.D. at 5%	1.64	2.22	0.94	2.09	0.58	0.68

*Significant differences as compared with the control.

Asana and Kale[34] with four varieties of wheat and George[35] with some cereal crops indicated that Ca content appreciably increased with increasing salinity.

The total nitrogen content of shoots and roots of pea nut decreased at all salinization levels, but the decrease was only significant at the highest level of salinization (7000 ppm). Hutton[25] with leguminous plants, Shimose[10] with rice, Heikal[17] with radish and Faheed[36] with some glycophytic plants reported that salinity resulted in a reduction in total nitrogen content.

Phosphorus content of shoots and roots of pea nut was decreased with the rise of salinization level, but the decrease was significant only at the relatively moderate and high salinization levels. This reduction is in accordance with the results obtained by Radi *et al.*[37], Heikal[17], Ahmed *et al.*[7] and Shaddad and Heikal[27].

Potassium content was reduced significantly only at the highest level (7000 ppm). This reduction was also reported by Melhrotra[38], Heikal[17] and Shaddad and Heikal[27]. The reduction in K content may be due to the high concentration of calcium in the culture media as reported by Allison[39], who reviewed that high concentration of Ca may restrict the uptake of potassium by beans and some carrot varieties.

Magnesium content of shoots and roots significantly decreased with the rise of salinization level and this is in agreement with the results obtained by Lashin and Atanasiu[16], Heikal[17] and Shaddad and Heikal[27]. The reduction in magnesium content was associated with an increase in calcium content and this may be due to high levels of calcium in saline nutrient solution added. Radi *et al.*[40] stated that the high calcium levels resulted in high calcium absorption and was generally associated with low power of magnesium absorption by tomato, maize and sunflower plants.

Therefore, the above discussion permits to state that pea nut plant can be tolerant to some extent to the relatively low and moderate salinization levels. Ahmed *et al.*[41] suggested that some of the oil producing plants can tolerate moderate of salinization levels.

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بعض الاستجابات الفسيولوجية لنبات الفول السوداني *Arachis hypogaea* لتأثير الضغوط الملحية

عبد الرحمن حجر ، مدحت هيكل ، يوسف مغربي و رضا أبو زنادة
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المستخلص . في هذا البحث تم دراسة تأثير مستويات مختلفة من الملوحة (صفر ، ١٠٠٠، ٣٠٠٠، ٥٠٠٠، ٧٠٠٠ جزء في المليون) باستخدام مخلوط من أوزان متساوية من كل من كلوريد الصوديوم وكلوريد الكالسيوم وذلك على إنبات بذور الفول السوداني . أيضًا تم استخدام المزارع الرملية وذلك لدراسة تأثير نفس المستويات السابقة من الملوحة على النمو وعلى محتوى الأصباغ النباتية وتركيز بعض العناصر المعدنية (صوديوم ، بوتاسيوم ، كالسيوم ، مغنسيوم ، فوسفور ، نيتروجين) وذلك في نبات الفول السوداني .

ووجد أن تلك المستويات من الملوحة ليس لها تأثير معنوي على إنبات بذور الفول السوداني . أما بالنسبة للأصباغ النباتية فقد وجد أن محتوى الأوراق من هذه الأصباغ يزداد بزيادة مستوى الملوحة . ووجد كذلك أن الوزن الجاف وكذلك تركيز معظم العناصر المعدنية قيد البحث في نبات الفول السوداني لا يتأثر جوهريًا بزيادة مستوى الملوحة حتى المستوى ٥٠٠٠ جزء في المليون ، وإن كان الوزن الطازج قد تأثر نوعًا ما عند هذا المستوى .