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MITIGATING SALINITY ADVERSE EFFECTS ON GUAR GROWN IN SANDY SOIL USING *RHIZOBIUM* INOCULATION AND P-APPLICATION

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ABSTRACT

A pot trial was performed in the summer seasons of 1997 and 1998 at the greenhouse of National Research Centre, , Dokki , Cairo, Egypt to study the effect of *Rhizobium* inoculation, P , various salinity levels and their interactions on growth, yield and chemical composition of guar grown in sandy soil. The obtained results show that *Rhizobium* inoculation, P-fertilization and their combinations significantly augmented growth parameters and the yield and its components, the highest increase was recorded due to the combined effect of both *Rhizobium* and P. A remarkable decrease in growth and yield parameters was observed due to the high salinity levels (6000 & 8000 ppm) where the percentages of decrease reached 46.4% and 91.9% respectively in plant height. Plants treated with 8000 ppm salinity level failed to form any pods while the decrease in seed yield/ plant treated with 6000 ppm salinity level reached 72.4% compared to the control. Inclusion of both *Rhizobium* and P to different salinity levels mitigated their effects on plant growth and its yield, where the plants treated with 8000 ppm recovered their ability for pod formation. Chemical composition of seeds and mineral contents of leaves were increased owing to *Rhizobium* and P- application except Na content in leaves. Gradual decrease was recorded N, P, K, Ca, Mg and Fe content in leaves with increasing salinity level while both Na and Zn were increased. The addition of both *Rhizobium* and P to the diverse salinity levels increased, to some extent, leaves content of N, P, K, Ca, Mg and Fe while relative decreases in Na content was recorded in comparison with the corresponding salinity levels.
Keywords: guar, *Cyamopsis tetragonoloba*, salinity, *Rhizobium*, inoculation, phosphorus.

INTRODUCTION

Guar or clusterbean *Cyamopsis tetragonoloba* (L.) Taub. is a summer annual leguminous crop characterized as deep-rooted moderately tolerant to drought and salinity and adapted to semi-arid climates(El-Otafee,1999 and Wistler and Hymowitz, 1979). It is originally grown in India and Pakistan, where many cultivars are cultivated and introduced to Egypt since 1950 where one cultivar called " Local Land Race" is present (El-Otafee,1999). Guar is mainly cultivated for seed, green fodder , vegetables and green manuring purposes (Bhadoria *et al.,*1997). In addition , it is an important economic plant where guar seeds are considered the principal source of guaran gum called " galactomannan " which is a polymer, consisted of galactose (36%) and mannose (64%) , repeatedly used in food industry as thickening agent, in pharmaceutical industry for lotions and creams and in the mining industry for the purification of potash , ore flotation and waterproofing of explosives (Alexander *et al*.,1988).

From the microbiological point of view, guar gum was found to retain the maximum number of *Azotobacter* on wheat and barley grains and its proliferation and distribution on roots (Suman *et al*.,1995). Despite of its low nutritional requirements and the paucity of problems caused by pests and diseases , guar has received little attention in Egypt where the total cultivated area ranges between 250 – 360 fed./year mainly in Upper Egypt governorates (El-Otafee, 1999).

The present work deals with studying the effect of *Rhizobium* inoculation and phosphorus application in the presence of different levels of salinity and their interactions on growth, yield, chemical composition, including guar gum (guaran) and nutrient content of guar plant cultivated in a sandy soil.

MATERIALS AND METHODS

A pot experiment was executed twice in the summer seasons of 1997 and 1998 at the greenhouse of the National Research Centre, Dokki, Cairo, Egypt. Plastic pots of 30 cm diameter, filled with 10 kg uncultivated low fertile sandy soil of the following characteristics: clay, 8.19%; silt, 6.40%; sand , 84.30%; organic matter, 0.09% ; pH, 7.41 ; total nitrogen, 0.015% ; total phosphorus, 0.038 % ; E. C. , 3.7 m mhos/cm^3 and total microbial count , 9.6 x10^2 CFU/gm dry soil.

Guar seeds were sown in the first week of June for both seasons at the rate of 5 seeds/pot. Phosphate-treated pots were received 2gm for each (200kg/fed. as calcium superphosphate) before cultivation then mixed with the soil. *Rhizobium*-treated pots were inoculated with 10ml liquid culture of *Rhizobium* sp. (the mother culture was kindly supported by Agricultural Research Centre) containing 6.4 x 10^7 cell/ml (2ml/seed) added directly on the seeds (*Gomaa,1989*) then covered with a thin layer of the soil. The uninoculated pots received 10 ml distilled water instead of rhizobial inoculum. Irrigation was carried out according to the need of plants either with tap or salinized water with a mixture of Na Cl and Ca Cl_2 (1:1W/W) to give the concentrations of 0, 1500 , 3000, 4500, 6000 and 8000 ppm where the complete design of the experiment is:

- Control.
- Superphosphate.
- *Rhizobium* sp.
- Superphosphate+ *Rhizobium* sp.
- Irrigation with 0, 1500, 3000, 4500, 6000 or 8000 ppm saline solutions.
- Superphosphate+*Rhizobium* sp. and saline solutions of 0, 1500, 3000, 4500, 6000 or 8000 ppm.

Each treatment was replicated five times in a complete randomized block design. After two weeks, guar seedlings were thinned to one plant/pot and then fertilized with a uniform dose of ammonium sulphate (20.5%) and potassium sulphate (48%) 0.3 and 0.6 gm/pot respectively (equivalent to one third of the recommended dose/fed.). Another one third dose of these fertilizers were added three weeks later of the first one. Plants were sampled at harvest time to measure the various growth and yield parameters as well as chemical composition of seeds and leaves.

Nitrogen content was determined using microkjeldahl method (A.O.A.C. 1970). Phosphorus was estimated according to the method described by Jackson (1960) and potassium was assayed using flamephotometer.

The other macro - and micro-elements (Ca , Mg , Na , Fe and Zn) were determined via Central lab of National Research Centre. Total carbohydrates were evaluated as glucose (Dubois *et al.,*1956). Fixed oil was determined according to the method described in A. O. A. C (1975) and guaran content was assayed according to Anderson (1949). The combined data of the two seasons were statistically analyzed according to the procedures of Snedecor and Cochran (1982) where the means of studied treatments were compared using L. S. D test at 0.05 significance level.

RESULTS AND DISCUSSION

It is well known that P-application has a favourable effect on plant growth due to either its direct effect on the plant where it is a major constituent of plant cell nucleus and growing root tips which helps in cell division and root elongation (Meena *et al.*, 1991) or its indirect impact on root-nodules bacteria (*Rhizobium*)and the other rhizospheric microorganisms that enhance plant growth. The previous facts interprete the significant increases in plant height, branches, number and weight of pods/plant, number of seeds/pod and per plant, seed yield/plant and seed and harvest indices (Table 1). It is clear from Table (1) that *Rhizobium* inoculation significantly augmented the same previous mentioned growth and yield parameters, where significant increases were recorded owing to the combined effect of both super- phosphate and *Rhizobium* inoculation as compared to the control. This could be attributed to the synergistic effect of both phosphorus and *Rhizobium* where phosphorus might have involved in basic reaction of photosynthesis, that affect plant growth and consequently seed yield. At the same time, *Rhizobium* is known to play a vital role in nodulation, biological nitrogen fixation and yield of leguminous plants *(Islam,1981*and *Sanoria* and *Mallik, 1981*). On the other hand, different salinity levels decreased growth and yield parameters, the decrease in plant height ranged from 30.6% at 4500 ppm to 91.7% at 8000 ppm while reached 33.3% and 100 % respectively at 3000 ppm and 8000 ppm for branches number per plant. It is worth mentioning that both concentrations of 1500 and 3000 ppm did not have harmful effect on plant height.

Table (1): Influence of P-application , *Rhizobium* inoculation , different salinity levels and their Interactions on growth and yield of guar.

Parameters / Treatments	Plant height (cm)	Branches (no./ plant)	Pods (no./ plant)	Pods (gm/ plant)	Seeds (no./ pod)	Seeds (no./ plant)	Seeds (gm/ plant)	Seed Index (gm)	HI
Control	61.5	1.2	14.6	5.95	6.70	97.8	3.69	3.40	39
Superphosphate (p)	75.6*	1.4*	17.6*	7.17*	7.00*	123.2*	4.36*	3.52*	48*
Rhizobium(Rh)	73.7*	1.4*	19.2*	7.87*	8.00*	153.6*	5.18*	3.49*	46*
P+Rh.	83.1*	1.6*	22.8*	8.69*	8.66*	197.5*	7.20*	3.54*	49*
Salinity (S)									
1500ppm (S_1)	63.1	1.2	12.3	5.79	6.68	82.2	3.03	3.43	38
3000ppm (S_2)	62.4	0.8	0.8	4.34	6.25	65.0	2.82	3.39	36
4500ppm (S_3)	42.7	0.4	5.1	3.31	5.71	29.1	1.37	3.45	27
6000ppm (S_4)	33.8	0.0	3.2	1.30	3.11	10.7	1.02	3.28	22
8000ppm (S_5)	5.1	0.0	0.0	0.00	0.00	000.0	0.00	0.00	00
P+ Rh + S_1	79.5*	1.4*	18.6*	6.97*	6.80*	126.5*	4.77*	3.72*	42*
P+ Rh + S_2	73.2*	1.4*	16.7*	6.95*	6.56*	109.6*	4.14*	3.75*	43*
P+ Rh + S_3	41.7	0.6	10.6	3.37	5.11	54.2	2.05	3.48	36
P+ Rh + S_4	33.6	0.2	3.5	2.04	4.41	15.4	1.13	3.38	29
P+ Rh + S_5	6.5	0.0	3.4	2.04	2.71	9.2	1.01	3.34	24
L. S. D 5%	7.4	0.06	2.1	0.92	0.95	12.1	0.40	0.09	3

HI : harvest index.

With regard to yield and its attributes, it was found that various salinity levels affected seed yield and its components as plants treated with 8000 ppm salinity level failed to form any pods while the reduction in seed yield ranged between 17.9% at low salinity level (1500 ppm) and 72.4% at high salinity level (6000 ppm) in comparison with the control. These observations are on the same line with those of Singh and Abrol (1986). *The c*ombined effect of both *Rhizobium* inoculation and phosphorus application in the presence of different salinity levels has been presented in Table (1). The recorded data clearly show that inclusion of both *Rhizobium* and phosphorus mitigated the adverse effect of salinity on guar where the reduction percent , in general, for various growth and yield parameters was lower when compared to the effect of different salinity levels alone. This result is in accordance with that obtained by El-Fayoumy *et al.* (1996) where they stated that seed inoculation increased grain yield by 18, 12 and 1.6% at salinity levels 2.67, 5.72 and 9.37 dS/m respectively over the uninoculated treatments. It is worth mentioning that reproductive organs were more seriously affected than vegetative ones where the plants treated with 8000 ppm salinity level completely failed to produce any pods while the addition of both *Rhizobium* and phosphorus to the plants treated with the same previous concentration lowered its unfavorable effect. A significant increase was recorded for growth and yield (Table 1) at low (1500 ppm) and moderate (3000 ppm) salinity levels, when *Rhizobium* and phosphorus were added. These findings were supported by Sanoria and Mallik (1981) and Islam (1981) where they found that inoculating lentil seeds with *Rhizobium* improved plant growth and yield, and concluded that the efficiency of

Rhizobium inoculation may be influenced by a number of factors such as availability of phosphorus and salinity.

The effect of P- application , *Rhizobium* inoculation, different salinity levels and their interactions on chemical constituents of guar seeds was illustrated in Fig. (1). It is clear from Fig. (1-a) that the percentage of protein in guar seeds was slightly affected by various treatments. The highest increase was recorded with the treatments of P+Rh+S_2, P+Rh+S_1 and P+Rh where their protein percents reached 30.6, 30.5 and 30.5% respectively against 29.5% for the control. Furthermore, inclusion of phosphorus and *Rhizobium* , especially to the high salinity levels, i.e. 6000 and 8000 ppm improved the protein percent of seeds when compared to the corresponding treatments of salinity. Such improvement could be attributed to the synergistic effect of *Rhizobium* that enhance N_2-fixation and P- application that activates translocation of photosynthates to the sink or sites of their requirements (*Singh* and *Singh, 1989*).

The same previous trend was recorded for the percentage of each of carbohydrate (Fig.1-b) , fixed oil (Fig. 1-c) and guaran (Fig. 1-d), where their minimum and maximum values ranged from 33.7 to 35.2% , 4.6 to 9.8% and 18 to 30.1% respectively.

With regard to the influence of P- application, *Rhizobium* inoculation, salinity levels and their interactions on mineral contents of guar leaves, Table (2) indicates that application of P and / or *Rhizobium* in most cases, significantly augmented studied macro-and micro-nutrients in guar leaves, except Na concentration, where the resultant values were insignificant when compared with the control.

Moreover, the highest significant increases in mineral contents of guar leaves were recorded due to the combined effect of *Rhizobium* and phosphorus. On the contrary, the mineral contents of guar leaves decreased, gradually with increasing salinity levels.

Both Na and Zn , showed an adverse trend as they increased with increasing salinity level. This observation is in agreement with those of *Singh* and *Abrol (1986*) and *Khan* and *Varshney (1989*) where they reported that higher soil ESP (exchangeable sodium percentage) for the first and increasing Na concentration and decreased K, Ca and N content of the plants.

As for the combined effect of P and *Rhizobium* in the presence of various salinity levels, table (2) show that the combinations of low and moderate salinity levels (1500 & 3000 ppm) increased significantly mineral contents of guar leaves except for both Mg and Na where the differences were not significant when compared either with the control or salinity levels treatment. Contrarily, the combinations of moderate and high salinity levels reduced mineral contents of guar leaves in comparison with the control, but when compared with the corresponding salinity levels as such , it was found that inclusion of both *Rhizobium* and P lowered the severity of salinity effect. Each of Na and Zn behaved differently where they increased with increasing different salinity levels. The previous results were supported by Francois *et al.,* 1990 and Gaballah and El-Zieiny, 1990.

Table(2):Mineral content of guar leaves as affected by P-application, *Rhizobium* inoculation, salinity levels and their interactions.

Elements / Treatments	Concentration (mg/gm dry matter)						Concentration (ppm)	
	N	P	K	Ca	Mg	Na	Fe	Zn
Control	25.6	10.5	35.2	19.1	2.9	2.8	480	25
Superphosphate(P)	30.5*	11.2*	37.6*	21.5*	3.1	2.6	480	28*
Rhizobium(Rh)	35.7*	13.1*	37.5*	21.4*	3.5*	2.3	520*	27
P+Rh.	35.8*	13.6*	37.8*	22.3*	3.8*	2.4	530*	32*
Salinity (S)								
1500ppm (S_1)	20.7	10.6	35.4	19.8*	2.7	2.9	490	30*
3000ppm (S_2)	19.7	10.5	35.5	19.3	2.7	3.5*	620*	40*
4500ppm (S_3)	18.9	9.9	32.6	15.2	2.2	6.1*	440	42*
6000ppm (S_4)	18.9	9.6	30.2	15.3	2.3	7.4*	400	48*
8000ppm (S_5)	17.8	6.3	28.7	13.6	1.9	8.1*	380	52*
Interaction								
P+ Rh + S_1	28.9*	11.5*	37.5*	21.4*	2.9	2.5	580*	30*
P+ Rh + S_2	27.8*	11.6*	38.2*	20.8*	2.8	2.8	640*	45*
P+ Rh + S_3	20.8	10.2	33.6	16.6	2.5	5.8*	460	48*
P+ Rh + S_4	20.2	10.3	32.3	15.4	2.6	6.3*	430	52*
P+ Rh + S_5	20.3	8.7	29.4	13.7	1.8	7.4*	350	55*
L. S. D 5%	1.7	0.28	2.1	0.57	0.3	0.15	35.9	2.6

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تقليل الآثار الضارة للملوحة على نبات الجوار النامى فى أرض رمليه باستخدام التلقيح بالرايزوبيم وإضافة الفوسفور

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أجريت تجربة أصص فى الموسم الصيفى لعامى 1997 & 1998 لدراسة تأثير كل من التلقيح بالرايزوبيم وإضافة الفوسفور والتأثير المشترك بينهما بالإضافة إلى دراسة تأثير تركيزات مختلفة من الأملاح (1500 و 3000 و4500 و 6000 و 8000 جزء فى المليون) سواء أضيفت على حده أو فى وجود الرايزوبيم والفوسفور على النمو والمحصول والتركيب الكيماوى للبذور ومحتوى الأوراق من العناصر فى نبات الجوار. وقد أوضحت النتائج أن إضافة الرايزوبيم أو الفوسفور أو كلاهما قد أدى إلى زيادة النمو والمحصول معنوياً بالنسبة لمعاملة المقارنة . هناك نقص تدريجى فى النمو والمحصول بزيادة تركيز الأملاح حيث بلغت نسبة النقص فى ارتفاع النبات 46.4 و 91.9% على التوالى لتركيزى 6000و 8000 جزء فى المليون ، أما بالنسبة للمحصول فقد أخفقت النباتات المعاملة بتركيز 8000 جزء فى المليون عن تكوين القرون . كذلك فإن محتوى البذور من البروتين والكربوهيدرات والزيوت ومادة الجواران قد إنخفض تدريجياً بزيادة تركيز الأملاح. أزداد محتوى الأوراق من العناصر المختلفة معنويا نتيجة المعاملة بالرايزوبيم والفوسفور بالإضافة إلى التأثير المشترك بينهما باستثناء عنصر الصوديوم الذى سجل نقصاً طفيفاً فى حين كانت الزيادات فيه معنوية نتيجة المعاملة بالتركيزات المختلفة من الأملاح باستثناء تركيز 1500جزء فى المليون بالإضافة إلى ذلك ازداد محتوى الأوراق من عنصر الزنك معنوياً بزيادة تركيز الأملاح. التأثير المشترك لكل من الرايزوبيم والفوسفور فى وجود التركيزات المختلفة من الأملاح أدى إلى زيادة محتوى الأوراق من العناصر المختلفة معنوياً - خصوصاً فى التركيزات المنخفضة والمتوسطة - عند المقارنة بتركيزات الأملاح فقط، أما فى حالة التركيزات المرتفعة (6000 & 8000 جزء فى المليون) فقد كانت الزيادات غير معنوية، يستثنى من ذلك عنصر المغنيسيوم حيث كانت الفروق غير معنوية بالنسبة إلى معاملة المقارنة.