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SOME NUTRITIONAL TRIALS TO IMPROVE THE YIELD AND SEED QUALITY OF SOYBEAN PLANT

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ABSTRACT

Three field experiments were conducted on soybean plants (variety klark). Two experiments were carried out in Sakha Agric. Res. Station during two successive seasons at 2000 and 2001. The third experiment was conducted in 7 locations at all over Egypt.

The research was to study the effect of the application of K, micronutrients(Fe, Mn and Zn EDTA) and the inoculation with composite contains N_2- fixing bacteria (*Rhizobium leguminozarum ficia R.l.f.)* in addition to the application of the recommended dose of N(50 Kg fad^{-1}, P_2O_5(45kg fad^{-1}) and inoculation with the specific N_2 fixing bacteria of soybean(*Bradyrhizobium japonicum B.j.)* before sowing. Such treatments were applied either alone or in combination.

The obtained results were as the follows: -

1. Soybean yield showed significant response to almost of treatments were applied at the different locations.
2. The foliar spray with micronutrients showed highly significant response in yield followed by K fertilization.
3. The highest yield of soybean was recorded by appling the combined treatments (the balanced fertilization).
4. Under application of recommended treatments in these experiments, no positive effect was observed when applied the biofertilizer *(R.l.f.)* on soybean yield. However, it had a residual effect, it increased N in soil after harvest.
5. Generally, most of the treatments was increased the mineral contents in soybean seeds.
6. The total means of the macronutrient percentage in soybean seeds were; N: 4.05, P: 0.95, K: 2.14. The micronutrients concentration in $mgkg^{-1}$ were; Fe: 132, Mn: 47, Zn: 75 and Cu: 20.

INTRODUCTION

Soybean plants (*Glycine max (L.) Merril)* is one of the essential crops in the world, because of its high protein (about 25%) and oil (about 40%). In Egypt, soybean planted area was about four thousand feddans during 1970-74; then the planted area increased rapidly until it reached a

peak of 147 thousand faddans in 1983. There after, it followed a gradual decline until it reached only 17 thousand faddans in 1999. Soybean yield per faddan remained stagnant throughout the last 20 years.

A strong competition from imports, offered at low prices, is one of the reasons that plays a damaging effect on soybean growing in Egypt. The mean of the import of soybean oil was about 79 thousand-ton (1996-1998) with the value of 51 million dollars. (**Abd el-Salam 2000).**

So, a quite remarkable increase is so needed to continue at a higher pace to decrease the import of soybean seeds. Besides increasing the planted area, a good fertilizing program is needed. As the experts estimate, 30 to 50% of crop production comes directly from fertilizer nutrient application. Fertilization trials were done to increase soybean yield, and quality, in the same time increasing the net return.

The nitrogen (N) requirement of soybean is one of the highest of the agronomic crops because of the high concentration of protein in the seed. Soybeans require about 3.5lb of N per bushel of seed produced (**Crop Insights 1999).** Soybean obtains the N by converting non-available N_2 gas from the air into plant as usable N with help of *bradyrhizobium japonicum* bacteria, which infect the roots and cause formation of round or oval-shaped nodules on roots. **Harper and Hageman (1972)** reported that soybean plants rely primarily on nitrate-N (soil N) during the first half of the season, and on N_2-fixation during the second half. **Harper (1974)** reported that about 25 to 60% of N in soybeans comes from symbiotic N_2 fixation, because about half of nitrogen comes from symbiotic fixation and the remainder should come from soil and/or fertilizer.

Concerning the effect of the fertilization with phosphorus and potassium, **Abdel-Hadi et al. (1984)** detected that fertilization with P and K significantly increased harvest index by 13% of the control treatment and increased significantly soybean K-uptake by 26% of the control treatment. **Texas Agricultural Extension (1999)** mentioned that under good conditions, the recovery of anual application ranges from 5 to 20 percent for phosphorus and 30 to 60 percent for potassium.

The beneficial effects of micronutrients application in Egypt was reported by **Monged et al. (2003b)** that found that there is a true need for micronutrients in many soil location of Egypt, hence the treated plants application showed high "net return" values.

El-Habbal et al. (1995) concluded that balanced fertilization system including micronutrients can optimized the use of N-fertilizers. The same conclusion was also found by **El-Akabawy et al. (2001).**

Concerning the effect of biofertilizers on soybean, many studies in

Egypt insured the beneficial effect of biofertilizer inoculation to soybean seeds before sowing; **Ahmed et al. (2002).**

Thus, this research is aimed , essentially, 1) increase soybean yield and quality by applied balanced fertilization including micronutrients and biofertilizers. 2) enhancing soil fertility and increasing the residual nitrogen for subsequent crops. As well as, reducing the pollution of the ground and water resources caused by fertilizers. 3) increasing the net return.

MATERIALS AND METHODS

Three field experiments were carried out; two experiments were conducted in Sakha Agricultural Research Station (Kafr El-Sheikh Governorate) during the two successive seasons of 2000 and 2001. The third experiment was conducted during 2002 season in 7 locations all over Egypt; El-Kome El-Akhdar (Behira Governorate), Shebeen El-Kome (Monofia Governorate), El-Mansoura (El-Dakahlia Governorate), Mashtoul (El-Sharkia Governorate), El-Wadi El-Gideed (El-Dakhla Governorate) and the last two experiments were conducted in Kafr-El-Zaiat (El-Gharbia Governorate); all cultivated with soybean.

Concerning the two experiments at Sakha; all the treatments received the recommended dose of N (50kg fad^{-1}), P (45kg P_2O_5 fad^{-1}) and the seeds were inoculation with nitrogen fixing bacteria (*Bradyrhizobium japonicum B.j.)*before sowing.

The treatments were as the follows:

1. The recommended treatment (the control).
2. The recommended treatment + K (24kg K_2O fad^{-1}).
3. The recommended treatment + (Fe +Mn +Zn) $0.6gL^{-1}$ in two sprays.
4. The recommended treatment +K (24kg K_2O fad^{-1}) + (Fe +Mn +Zn) $0.6gL^{-1}$ in two sprays.
5. The recommended treatment + seed inoculation with *Rhizobium leguminozarium ficia (R.l.f.).*
6. The recommended treatment + K (24kg K_2O fad^{-1}) + inoculation with *Rhizobium leguminozarium ficia (R.l.f.).*
7. The recommended treatment + (Fe +Mn +Zn) $0.6gL^{-1}$ in two sprays + inoculation with (*Rhizobium leguminozarium ficia (R.l.f.).*
8. The recommended treatment + K (24kg K_2O fad^{-1}) + (Fe +Mn +Zn) $0.6gl^{-1}$ in two sprays + inoculation with (*Rhizobium leguminozarium ficia (R.l.f.).*

Each treatment repeated 4 times and arranged in complete

randomized block design.

The micronutrients treatment was a combination of chelated compounds of Fe. Mn and Zn with the ratio of 1:1:1 (using 0.2gm of each element per liter in two sprays). The first sprays was at 45 days from sowing and the second spray was at month later.

Soil surface samples (0-30) were taken from the experimental fields before sowing and after harvest to determine some soil properties according to **Jackson (1973)** as shown in Table 1 and Table 8.

At harvest, seed yield was determined as ton fad^{-1}. The seeds were subjected to some chemical analyses i.e. total N was determined according to the **A.O.A.C. (1990),** P according to **Jackson (1973),** K by flame photometer according to **Chapman and Pratt (1961).** Micronutrients were measured by Atomic Absorption Spectrophotometer.

The field experiments, which conducted in the 7 locations, followed the same treatments as of the previous experiments at Sakha. The area of each experiment was faddan divided to 8 strips each one represents a treatment. The obtained data were exposed to the proper statistical analysis of variance according to **Snedecor and Cochran (1980).**

Table (1): Some physical and chemical properties of the experimental soil.

Properties		Available nutrients (mg kg^{-1})		Anions and cations (mg100g $soil^{-1}$)	
C.S.	1.28				
F.S.	20.89	N	42.0	HCO^-	0.99
Silt (%)	48.87	P	6.0	CL^-	5.70
Clay (%)	28.96	K	362	SO_4^{--}	1.24
$CaCO_3$ (%)	3.22	Fe	16.84	Ca^{++}	3.79
OM (%)	2.14	Mn	18.74	Mg^{++}	2.57
pH	7.41	Zn	0.62	Na^+	1.54
EC (1:5)	1.64	Cu	5.22	K^+	0.03

RESULTS AND DISCUSSION

A. Seed yield quantity:

1. Effect of potassium:

Data presented in Table (2) indicates that the response of soybean to K was significant especially during 2000 season and also in the means of the two seasons; 2000&2001. The same finding was obtained by **Abdel-Hadi et al. (1984).** However, data in Table (3) shows low response to K application except in two locations; Shebeen El-Kome and El-Dakhla, which recorded 10 and 25% increase in yield more than the

control respectively. That may be due to the difference between the location's soils while Sakha (Table 2) has heavy textured soil, which needs more K than the other localities (**Abdel-Hadi 1988),** and El-Dakhla has a very poor soil (**Monged et al. 2003a).**

2. Effect of micronutrients:

The foliar spray treatments with micronutrients show highly significant increase of soybean yield than the control in all the experiments (Tables 2&3) Similar results were recorded in Egypt by **Monged et al. (2003 a&b).** Such need of soybean, and other crops, to micronutrients in Egypt may be due to several reasons; the great nutritional need of the high productivity of the recent crops, the discontinuity of the precipitation of the Nile mud, the intensive cropping system used and the high pH value of most Egyptian soils which hinders the utilization of most of micronutrients by plants **(Hamissa and Abdel-Salam1999).**

Table (2): Soybean yield (ton fad^{-1}) as affected by different treatments

Season	2000		2001		Mean	
B.J.+N+P+K+(Fe,Mn,Zn)+*R.l.f.*	yield	Seed index	yield	Seed index	yield	Seed index
+ + +	1.255	13.40	1.299	13.69	1.277	13.55
+ + + +	1.302*	15.21	1.309	15.37	1.305*	15.29
+ + + - +	1.412**	13.41	1.412**	14.67	1.412**	14.04
+ + + + +	1.462**	14.63	1.482**	13.10	1.472**	13.87
+ + + - - +	1.202	14.66	1.237	15.47	1.220	15.07
+ + + + - +	1.187	14.01	1.206	12.33	1.197	13.17
+ + + - + +	1.263	11.92	1.276	12.28	1.269	12.60
+ + + + + +	1.300*	11.78	1.303	11.59	1.302*	11.69
L.S.D. .05:	0.036		0.038		0.025	
.01:	0.050		0.052		0.033	

Notes: (*Bradyrhizobium japonicum*) : (*B.j.*)
(*Rhizobium leguminozarum ficia*) : (*R.l.f.*)

3. Effect of balanced fertilization:

The combination of fertilizing with NPK and foliar spray with micronutrients (Fe+ Mn+ Zn) recorded highly significant increases in soybean yield more than the control in all the experiments (Tables 2&3). Such results showed the great need for the balanced nutritional programs. The same finding was found by **El-Aggory et al. (2000) and Monged et al. (2003a).**

Table (3): Soybean yield (ton fad^{-1}) as affected by different treatments in seven locations during 2002 season.

Governorates	El-Behaira	El-Manofia	El-Dakhla	El-Garbia	El-Garbia	El-Sharkia	El-Dakahlia	Mean of
Treatments Location	El-Kom El-Akhdar	Shebeen El-Kom	El-Wady El-Gadeed	Kafre El-Ziat 1	Kafre El-Ziat 2	Mashtool	El-Mansoura	Treatments
B.J.+N+P+K+(Fe,Mn,Zn)+*R.l.f.*	yield	yield	yield	yield	yield	yield	yield	yield
+ + +	1.000	1.280	1.120	1.400	1.488	1.708	2.055	1.436
+ + + +	1.000	1.410	1.400	1.400	1.505	1.788	2.016	1.503
+ + + - +	1.200	1.440	1.484	1.488	1.488	1.808	2.080	1.570**
+ + + + +	1.300	1.480	1.680	1.575	1.587	1.878	2.117	1.660**
+ + + - - +	1.100	1.360	1.232	1.575	1.540	1.838	1.975	1.517
+ + + + - +	1.200	1.200	1.400	1.488	1.540	1.798	2.004	1.519
+ + + - + +	1.200	1.280	1.624	1.540	1.517	1.878	2.088	1.590**
+ + + + + +	1.400	1.380	1.764	1.540	1.587	1.888	2.130	1.670**
Mean of locations	1.175	1.354	1.463	1.501	1.531	1.823	2.058	

Notes: For treatments L.S.D.:.05 = 0.093
.01 = 0.125
(*Bradyrhizobium japonicum*) : (*B.j.*)

For locations L.S.D.: .05 = 0.087
.01 = 0.116
(*Rhizobium leguminozarum ficia*) : (*R.l.f.*)

4. Effect of biofertilizer addition:

The data presented in Tables (2&3) shows that using the biofertilizer (*Rhizobium leguminozarium ficia*) either alone or with K application decreased the yield significantly less than the control. That may be because the soybean seeds were inoculated with the specific biofertilizer of soybean (*Bradyrhizobium japonicum*) which may competed or inhibited each other as mentioned by **Bhalla and Sen (1973)** who found that several soil microorganisms and bacteriophages are known to inhibit the growth of rhizobia. Recently, **El-Haddad et al. (1998)** found that certain rhizobia are capable of inducing nodule formation on the roots of hosts than their habitual one.

Application of micronutrient to plant in addition to the inoculation with the biofertilizer (*R.l.f.*) resulted in a highly significant increase in yield (Table 3). That may be as a result of the beneficial effect of micronutrients used on the biofertilizers as mentioned by **Amara (1998)** who found that spraying with micronutrients resulted in a large increase in total microbial counts in the rhizosphere and increased nodule numbers and weights.

Combination of K fertilization, micronutrients sprays and inoculation with the biofertilizer (*R.l.f.*) increased the yield highly significant in all the experiments (Tables 2&3). However, the balanced fertilization treatment were more or less the same. That means, using the biofertilizer (*R.l.f.*) seams to be of no use when using (*B.j.*) with soybean beside the balanced fertilization which was emphasized by **Fawzi et al. (2000)** and **El-Aggory et al. (2001).**

5. The effect of treatments on seed index.

Table (2) illustrates that no clear trend can be noticed concerning the effect of the treatments on seed index that may be because it is hereditary character.

B. Yield quality:

Data in Tables (4&6) shows that, generally, N, P, and K concentrations and contents were increased as a result of all treatments. The highest increases were in the case of the spraying with the micronutrients in addition to the biofertilizer (*R.l.f.*).

Concerning Fe and Zn concentrations and contents (5&7) they were increased as a result of all the treatments but in different degree. However, Mn was less than the control in all the treatments. Cu concentration and content were more or less as the control. Similar results were conceded with those of ; **Soliman et al. (1995)** and **Sharma and Parma (1997).**

Table (4): Concentrations and contents of NPK in soybean seeds grown in Sakha during 2001 season as affected by different treatments.

Treatment	N		P		K	
B.J.+N+P+K+(Fe,Mn,Zn)+*R.l.f*	%	Kg fad^{-1}	%	Kg fad^{-1}	%	Kg fad^{-1}
+ + +	2.96	37.80	0.73	9.32	1.96	25.03
+ + + +	2.72	35.50	0.65	8.48	1.80	23.49
+ + + - +	4.34	61.28	0.89	12.57	2.05	28.95
+ + + + +	4.24	62.41	0.82	12.07	1.95	28.70
+ + + - - +	3.26	39.77	1.13	13.79	2.86	34.89
+ + + + - +	5.10	61.05	1.40	16.76	3.78	45.25
+ + + - + +	3.12	40.73	0.93	11.80	1.92	24.36
+ + + + + +	3.98	51.82	0.85	11.07	1.88	24.48

Notes: (*Bradyrhizobium japonicum*): (*B.j.*)
(*Rhizobium leguminozarum ficia*): (*R.l.f.*)

Table (5): Concentrations and contents of Fe, Mn, Zn and Cu in soybean seeds grown in Sakha during 2001 season as affected by different treatments.

Treatment	Iron Fe		Manganese Mn		Zinc Zn		Cupper Cu	
B.J.+N+P+K+(Fe,Mn,Zn) +*R.l.f*	mg kg^{-1}	g fad^{-1}	mg/k g^{-1}	g fad^{-1}	mg kg^{-1}	g fad^{-1}	mg kg^{-1}	g fad^{-1}
+ + +	98	125.15	77	98.33	62	79.17	21	26.82
+ + + +	116	151.38	53	69.17	72	93.96	22	28.71
+ + + - +	130	183.56	51	72.01	70	78.84	16	22.60
+ + + + +	125	184.00	48	70.66	70	103.04	15	22.08
+ + + - - +	109	132.98	48	58.56	79	96.38	21	25.62
+ + + + - +	103	123.29	48	57.46	77	92.17	17	20.35
+ + + - + +	131	166.24	52	65.99	93	118.02	21	26.65
+ + + + + +	129	167.96	54	70.31	90	117.18	23	29.95

Notes: (*Bradyrhizobium japonicum*): (*B.j.*)
(*Rhizobium leguminozarum ficia*): (*R.l.f.*)

Table (6): Concentrations and contents of NPK in soybean seeds grown in El-Wadi El-Gadeed during 2002 as affected by different treatments.

Treatment	N		P		K	
B.J.+N+P+K+(Fe,Mn,Zn)+*R.l.f*	%	Kg fad^{-1}	%	Kg fad^{-1}	%	Kg fad^{-1}
+ + +	3.78	42.34	0.76	8.51	1.72	19.26
+ + + +	4.69	65.66	0.94	13.16	1.96	27.44
+ + + - +	4.48	66.48	1.41	20.92	2.33	34.58
+ + + + +	4.06	68.21	0.96	16.13	2.07	34.78
+ + + - - +	4.62	56.92	0.82	10.10	1.80	22.18
+ + + + - +	4.76	66.64	0.87	12.18	1.96	27.44
+ + + - + +	4.08	77.95	0.90	14.62	2.03	32.97
+ + + + + +	4.52	79.73	1.02	17.99	2.03	35.81

Notes: (*Bradyrhizobium japonicum*): (*B.j.*)
(*Rhizobium leguminozarum ficia*): (*R.l.f.*)

Table (7): Concentrations and contents of Fe, Mn, Zn and Cu in seeds of soybean grown in El-Wadi El-Gadeed during 2002 season as affected by different treatments.

Treatment	Iron Fe		Manganese Mn		Zinc Zn		Cupper Cu	
B.J.+N+P+K+(Fe,Mn,Zn) +*R.l.f.*	mgkg^{-1}	g fad^{-1}	mgkg^{-1}	g fad^{-1}	mgkg^{-1}	g fad^{-1}	mgkg^{-1}	g fad^{-1}
+ + +	133	148.96	38	42.56	74	82.88	26	29.12
+ + + +	127	177.80	32	44.80	77	107.80	21	29.40
+ + + - +	113	167.69	43	63.81	82	121.69	23	34.13
+ + + + +	109	183.12	41	68.88	63	105.84	17	28.56
+ + + - - +	240	295.68	43	52.98	75	92.40	20	24.64
+ + + + - +	235	329.00	42	58.80	70	98.00	17	23.80
+ + + - + +	101	164.02	38	61.71	72	116.93	17	27.61
+ + + + + +	108	190.51	43	75.85	68	119.95	17	29.99

Notes: (*Bradyrhizobium japonicum*): (*B.j.*)
(*Rhizobium leguminozarum ficia*): (*R.l.f.*)

Table (8): Available elements in soil (0-30 cm) after soybean harvest in Sakha during 2001 season.

Treatment	Macronutrients (mg kg^{-1})			Micronutrients (mg kg^{-1})			
B.J.+N+P+K+(Fe,Mn,Zn)+*R.l.f.*	N	P	K	Fe	Mn	Zn	Cu
+ + +	29.4	23.3	323	23.14	12.36	0.52	5.26
+ + + +	32.2	34.7	411	19.18	8.38	0.28	4.32
+ + + - +	26.6	9.7	352	23.52	9.96	0.42	4.98
+ + + + +	43.4	10.7	281	20.20	9.60	0.38	4.92
+ + + - - +	28.0	12.3	323	27.40	11.78	0.66	6.54
+ + + + - +	82.6	13.0	323	22.30	9.28	0.44	4.72
+ + + - + +	56.8	16.7	323	20.68	10.38	0.48	5.38
+ + + + + +	54.6	11.33	332	20.14	9.56	0.28	4.30

From the obtained results it could be mentioned that the average concentrations of the minerals in soybean seed are: N 4.05%, P_2O_5 0.95%, K_2O 2.14%, Fe 132 mg/Kg^{-1}, Mn 47 mg/Kg^{-1}, Zn 75 mg/Kg^{-1} and Cu 20 mg/Kg^{-1}.

C. Concentration of the minerals in the soil at harvest.

It was found from (Table 6) that, N concentration was higher than the control after the treatments that were inoculated with *(R.l.f.),* K and micronutrients that may be of great benefit to the consequent crops; these results are in agreement with that obtained by **Mugabe (1994).** However, the other minerals were deprived from the soil. So it should be taken into consideration of fertilizing program for the subsequent crops follow soybean.

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بعض معاملات التغذية لتحسين محصول و جودة بذور فول الصويا

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أقيمت ثلاث تجارب حقلية على نبات فول الصويا. اثنتان أجريتا في محطة البحوث الزراعية بسخا خلال موسمي ٢٠٠٠، ٢٠٠١ . والتجربة الثالثة نفذت خلال موسم ٢٠٠٢ في سبع مواقع هي: الكوم الأخضر (محافظة البحيرة)، شبين الكوم (محافظة المنوفية)، المنصورة (محافظة الدقهلية)، مشتول (محافظة الشرقية)، الوادي الجديد (محافظة الداخلة)، و موقعان في كفر الزيات (محافظة الغربية).

وكان الهدف من التجارب هو دراسة تأثير إضافة السماد البوتاسي بمعدل ٢٤كجم/فدان. والرش بالعناصر الصغرى (حديد والمنجنيز والزنك) بمعدل ٠,٦ جم/لتر من المخلوط المتساوي من العناصر المخلبية و كذلك اختبار تأثير التلقيح البكتيري للبذور بمخصب حيوي مثبت للأزوت الحوي (*Rhizobium leguminozarum ficia*). إما في معاملات مفردة أو في معاملات متداخلة. وقد تم دراسة تأثير هذه المعاملات على المحصول و وزن المائة بذرة و المحتوى العنصري للبذور (النيتروجين و الفسفور و البوتاسيوم و الحديد و المنجنيز و الزنك و النحاس). مع ملاحظة أن جميع المعاملات من تلقيح بكتيري لفول الصويا (*Bradyrhizobium (japonicum*) قبل الزراعة و التسميد النيتروجيني

(٥٠كجم/فدان و التسميد الفسفوري (٤٥كجم/فدان) كانت معاملات موصي بها.

و كانت أهم النتائج المتحصل عليها ما يلي:

١. أدت أغلب المعاملات تحت الدراسة إلى زيادة معنوية في المحصول.
٢. كان للرش بالعناصر الصغرى تأثيرا معنوي عل المحصول في جميع المعاملات مما يدل على أهمية المعاملة بهذه العناصر للنبات تلى ذلك التسميد البوتاسي.
٣. إضافة التسميد المتزن من النيتروجين و الفوسفور و البوتاسيوم مع الرش بمخلوط الحديد و المنجنيز و الزنك مع التلقيح البكتيري بالبكتريا الخاصة بفول الصويا (*B. j.*) أدى إلى أعلى زيادة في المحصول.
٤. لم يكن لاستعمال سماد حيوي إضافي مثبت للأزوت الجوي تأثير إيجابي على المحصول و إن كان له أثر باقي في التربة بعد الحصاد.
٥. يمكن القول بصفة عامة أن أغلب المعاملات أدت إلى زيادة تركيز العناصر في البذور مما أدى إلى زيادة جودتها.
٦. أن متوسط تركيز العناصر كما يلي: ٤,٠٥ ن./.، ٠,٩٥ ./.فو ،٢,١٤ ./.بو ، ١٣٢ ح جزء في المليون، ٤٧ منجنيز جزء في المليون، ٧٥ زنك منجنيز جزء في المليون ، ٢٠ نحاس منجنيز جزء في المليون.