ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

EFFECT OF BIOFERTILIZER, NITROGEN, AND PHOSPHORUS ON IRRIGATED SOYBEAN (*Glaycine* max) IN GEZIRA-SUDAN

Abdalmohsin Rizgalla Khairalseed
Department of Chemistry and Soil, Faculty of Agriculture, University of Sinnar, Sudan
E-Mail: rizgalla2006@gmail.com

ABSTRACT

This experiment was conducted at the Gezira research station to examine the effect of composite strains of rhizobia (TAL102, TAL379and TAL 377) carried on peat used for soybean (*Glaycine* max) inoculation. Nitrogen and phosphorus were used at different levels to determine the effect on the soybean number of nodules, shoot dry weight soybean yield, nitrogen percentages, and crude protein. The most probable number (MPN) was used to determine the number of the rhizobium per gram on the peat. Treatments were factorially combined and laid out in a complete block design. Seed inoculation increased nodule dry matter and nitrogen fixation. Added 50Kg N/ha to inoculated soybean decreased nodule dry mass and doubling the dose further decreased the nodule dry mass. Adding 50KgP_2O_5/ha to inoculated soybean significantly increased soybean shoot dry mass over mere inoculation. Inoculation alone significantly increased soybean seed yield over that the control and gave the same seed yield over that of inoculated with 100KgN/ha. Inoculation with 50KgN/ha significantly increased seed yield over that of the inoculated soybean. Effect of different treatments on crude protein percentage (CP %) followed the same trend as for seed N%.

Keywords: soybean, biofertilization, N and phosphorus fertilizers.

INTRODUCTION

Soybeans have being consumed as foods for 100's of years before they were used as raw materials for the processing industry. There are different types of soybean foods some of which have become traditional and popular daily meal items in East Asia. These include soybean curd, fermented soybean soup, fermented soybean or roasted' flour soybean. The soybean grain contains about 40% protein and 21% oil as well as vitamins Lecithin, Ca, K and P. Soybean is a fast growing item in the world trade. Bell [1] reported that the volume of world trade in soybeans and soybean products amounted to 35.5 million metric tons in 1977-78. This was 66% higher than 5 years earlier and worth more than 8.5 billion dollars. Tatayoshi and Peter [2] reported that the world annually produced 28.6 million metric tons of soybean in 1961-65 and reached 217.6 million metric tons in 2005-2007 i.e. the quantity increased 7.6 times during the half a century. The increase in world consumption of soybean in recent years is the result of rapid growth in world demand for higher protein feed and an expansion in world demand for edible vegetable oil. For this reason the demand for soybean is increased Research in cultivating soybean in Sudan began in the early 70's with the introduction of various varieties from U.S.A. and through the participation of the Sudan in the cooperative INTSOY varietal testing program. Nevertheless, cultivation of soybeans in Sudan using seed and soil inoculants has been tried since the beginning of this century with inoculants introduced from various countries (Mukhtar and Abu Naib) [3] As a leguminous crop, soybean is believed to have the capacity to secure most of its N requirements through the fixation of atmospheric N2 in symbiosis with rhizobia if properly inoculated with efficient strains. Khalifa [4] attributed the superiority of the irrigated system over the rainfed system in grain yield production of soybean to better nodulation which was reflected by large and heavier nodules not detected in Sudan soils (Mukhtar and Abu Naib) [3] Duly research in the Sudan stated that for successful production of soybean in the Sudan it is essential to introduce efficient rhizobia with the crop. The introduced strains should be effective, able to compete with the native rhizobia and adapt with the Sudan climate. The amount of nitrogen fixed by soybean varies widely. Soybean can fix between 14 and 300 kg N/ha depending on its yield potential, availability of soil N and the interaction of the host variety and the *R. japonicum* strain.

Sudanese soils are known to be low in N. Several investigators claimed that a starter dose of N fertilizer further increases the yield of well nodulated soybeans. Determining the level and time of application of N fertilizer at which nodulated soybeans in Sudan Gezira will give maximum seed yield is important. Available P. of the Sudan Gezira soil is also low. Although some researchers showed a clear evidence of linear response of soybean yield to moderate rate of P fertilization on soils having low available P, others found that grain yield of soybeans was not significantly affected by P fertilization at 50 kg P_20_5/ha. Hittle [5] reported that the high yield potentials of soybeans together with the diversity of tropical lands suiting its cultivation requires the introduction of effective *R. japonicum* strains that are adaptable to specific soil environments. Suba Rao [6] reported that soybean responds well to inoculation with *R. japonicum* especially in soils where the crop is being introduced for the first time.

The objectives of this research were

a) To investigate the influence of inoculation on soybean nodulation, nitrogen fixation, protein content of the soybean seed and dry matter yield
b) To examine the effect of N and P fertilization on soybean nodulation, N2-fixation and soybean yield

ARPN Journal of Agricultural and Biological Science

Determination of N% and crude protein as affected by different treatments

MATERIALS AND METHODS

Three strains of *Rhizobium japonicome*. These strains carried on peat were used in this study i.e. (TAL102, TAL377, TAL379) carried on beat were obtained from (Niftal Project, University of Hawaii.) A composite of the three strains. That strains carried onbeat, as well as different levels of N and P were also used in this study the soybean varity employed in this study was Davis.

Most probable number (MPN)

For the determination of the viable rhizobia in the beat based inoculums the MPN method described by Somasegaran [and hoben [7] was used.

Plot layaut

The experiment was conducted at the Gezira Research Station Farm -the soils are heavily cracking clays with 55% clay and are classified as vertisols having alkaline reactions (pH 8.4). Said [8]. A randomized complete block design with 4 replicates was used. The individual subplot dimensions were 2.4 x 6 m^2 with four 60 cm-ridges. Subplots were separated by 1 .2 m space to avoid lateral movement of both inoculant and the added N from one subplot to another.

Treatments

Treatments used include:

1. Seed inoculation
2. Phosphorus fertilization
3. Nitrogen fertilization

where there were: 2 levels of inoculation = inoculated and noninoculated seeds.
P with 3 levels: 0 and 50. Kg P_2O^5 50/ha
N with 3 levels: 0, 50 and 100 kg N/ha.

The treatments were factorially combined and laid in a complete block design.

1. C	Control
2. N-I	50 kg N/ha
3. N-2	100 kg N/ha
4. P	50 kg P_2O^5/ha
5. N-I+ P	50 kg P_2O_5+50 kg N/ha
6. N-2+P	50 kg P_20_5+100 kg N/ha
7. I	Seed inoculation
8. l+N-1	Seed inoculation + 50 kg N/ha
9. I+N-2	Seed inoculation + 100 kg N/ha
10. I+P I	Seed inoculation + 50 kg P_2O_5/ha
11. I+P+N-1	Seed inoculation + 50 kg P_2O_5÷50 kg N/ha
12. I+P+N-2	Seed inoculation + 50 kg P_20_5+100 kg N/ha

Thus treatments were placed in one block east to west along the field. This was then replicated 4 times north-south.

Seed inoculation

Preparation of gum Arabic sticker

100 ml of distilled water was heated to near boiling. Gum Arabic was added in small lots (1-2 g) with continuous stirring until 40 gms of the gum were dissolved. The solution was kept till use.

Inoculant application rate and inoculation procedures

5g peat inoculant per 100 g seed was used. For each experiment 3 kg soybean seeds were placed in a clean plastic container for inoculation. Gum Arabic solution was added in small amounts and mixed with the seeds till the seeds were coated with the solution (3 ml gum Arabic solution/100 gram seeds) and then the inoculant was added and mixed thoroughly with the seeds. Seeds were allowed to air dry on clean paper in the shade.

Plot procedures

To minimize rhizobial contamination, uninoculated seeds were sown first. Soybean seeds were sown at the Gezira Research Station Farm Gezira. Seeds were sown on 60 cm ridges with 5 cm between plants, 3 cm deep and covered manually with soil. Then equivalent to 50 kg1 N/ha and 100 kg N/ha and 50 kg P_20_5/ha was broadcast on the ridges. The plots were irrigated within 24 hours from sowing. Irrigation then continued every 7-9 days when there were no rains.4-5 hand weedings were carried out during the season. Plant samples were taken after 4, 6 and 8 weeks from sowing, and a 4th was sample was taken at harvest. These samples were taken from the two outer ridges of each subplot and the two inner ridges were left for yield determinations. A small spade was used to dig the plants out to avoid nodule loss during sampling. The roots of each plant were washed in the canal water and plants were taken to the laboratory where roots were separated from shoots and nodules were harvested from plant roots, dried and their air dry weights were determined. Shoots were oven dried at 65°C and their oven dry weights were determined. Total % N in plant shoots was determined, using Micro-Kjeldahl method as described by Michell [9] Phosphorus was determined by the method of Chlorostannus reduced molybdophosphoric blue colour in hydrochloric acid system Jackson, [10] Plants in the two inner ridges of each subplot were collected and weighed for total biological yield, then the seeds were separated and weighed for grain yield. Seed nitrogen content was determined and concequently seed crude protein percentage (CP %) was calculated as N % x 6.25.

RESULTS

Field study

ISSN 1990-6145
ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

Viable Rhizobium population in the inoculant used

The inoculant used was subjected to both the most probable number (MPN) and plate count evaluation as a quality control measure. The MPN determination gave the value of 1.0 x107 viable rhizobial cells while the plate counts gave a value of 3.7 x108 both for one gram of inoculant.

Nodulation (ND)

Nodulation was studied 3 weeks after sowing. Nodules were large 3-6 mm in diameter, red in colour from inside and most of them (90%) were found on the main root, thus indicating a good degree of efficiency. Data in Table-1 showed the mean nodule dry matter as affected by different treatments. It is evident that nodule mass increased much from 4 to 6 to 8 weeks samplings. It almost increased 4 folds from 4 to 6 weeks and doubled from 6 to 8 weeks.Adding N-1 decreased nodule dry matter whereas N-2 further decreased the nodule dry mass as shown by T8 (I + N-1) and T9 (I + N-2) respectively. The latter were significantly (P 0.05) lower than T7. at 4 and 6 weeks, but no significant differences were observed at 8 weeks.

Table-1. Average nodule dry matter (mg/plant) as affected by different treatment at different intervals from sowing.

Treatments		4 weeks S1	6 weeks S2	8 weeks S3
T7	Inoculation	3.50 b*	13.00a	24.00 ab
T8	I + N -1	1.75 c	7.25 b	29.00 ab
T9	I + N -2	1.25 c	6.75 b	16.00 b
T10	I + P	5.50 a	7.50 b	35.00 a
T11	I + P + N -1 + P	3.00 b	5.00 b	27.00 ab
T12	I + P + N -2 + P	2.03 b	3.00 b	27.00 ab
SE ±		0.56	1.34	4.02

*Duncan Multiple Range Test (DMRT): Means within the same column having common letter are not significantly different at 5% probability.

Adding P to inoculated soybeans (Tb) significantly (P 0.05) increased nodule dry matter over those of all other treatments at 4 weeks and it resulted in the highest NDM over all treatments at 8 weeks and only second to inoculation at 6 weeks. Treatments 11 and 12 were not significantly different from each other at all the 3 sampling dates, although at 4 and 6 weeks T1l gave 47% and 66% more NDM than T12 at 4 and 6 weeks respectively. The differences between all treatments decreased at 6 weeks to an almost insignificant level.

Shoot dry matter (DM)

Data on shoot dry matter is given in Table-2. Differences between inoculated and uninoculated treatments were small at 4 and 6 weeks but they were clearly significant at 8 weeks, thus inoculation (T7) increased shoot dry matter over that of the control (T1) at 4 and 6 weeks, but the increments were insignificant. At 8 weeks the differences were significant. No significant differences were noted between Ti (control) and T2 (N-1) at 4, 6 and 8 weeks as far as DM is concerned. Treatment 3 (N-2) was also not significantly different from Ti (Control), and T2 (N-1) at 4 and 6 weeks but it was significant (P = 0.05) at 8 weeks. Phosphorus alone resulted in no significant differences from Ti at the 3 sampling dates. Phosphorus and nitrogen combined at both levels of N (T5 and 6) werenot significantly different between themselves at 4 and 6 weeks in DM produced, but at 8 weeks T6 (P + N-2) was significantly (P = 0.05) higher than both T4 (P) and T5 (P + N-2). Adding N-1 to both inoculated and uninoculated soybean resulted in similar amounts of DM at 4 weeks. At 6 weeks from sowing, however, the inoculated soybean with added N-i produced 51% more DM over that of uninoculated soybean plus N-1. This difference is statistically significant (P 0.05) at 8 weeks. Adding N-2 to inoculated soybean T9 significantly (P 0.05) increased DM over that of inoculated soybean plus N-1 (TB) at 4 weeks but no significant differences were observed at 6 and 8 weeks. Adding P to inoculated soybean did not result in extra DM production as compared to mere inoculation at 4 and 6 weeks.

ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

Table-2. Shoot dry matter of soybean plants as affected by different treatments (grams/ plants) at 4, 6 and 8 weeks.

Treatment		**Seed nitrogen** (%)	**Seed protein** (%)	**Total protein production/ hectare** (Tons/ha)
T1	Control	0.62 cd*	4.40 ab	7.15 f
T2	N – 1	0.72 bcd	4.15 ab	9.28 ef
T3	N – 2	0.93 abc	3.53 b	12.48 cde
T4	P	0.56 ab	4.08 ab	9.59 ef
T5	P + N – 1	0.96 ab	4.15 ab	9.21 ef
T6	P + N – 2	0.83 abcd	5.93 ab	16.17 bc
T7	Inoculation	0.79 abcd	4.80 ab	12.24 de
T8	I + N -1	0.71 bcd	6.33 a	16.17 bc
T9	I + N -2	1.06 a	6.85 a	12.77 cd
T10	I + P	0.85 abcd	4.53 ab	20.13 a
T11	I + P + N -1	0.81 abcd	5.50 ab	19.24 ab
T12	I + P + N -2	0.77 abcd	6.30 ab	14.23 cd
SE ±		0.1	0.85	1.18

* DMRT: Means within the same column having common letters are not significantly different at 0.05 level.

By week 8, however, adding P had significantly (P = 0.05) increased plant DM production over inoculation alone. Treatment 10 (I + P) and T1l (I + P + N-1) were not statistically different at the 3 sampling dates in DM. Treatment 12 (I + P + N-2) was not different from Ti0 and T1l at 4 and6 weeks, but it was significantly lower than Ti0 and Tl1 at 8 weeks in DM but not so in the 2 early sampling samplings.

Shoot nitrogen content

Some significant differences were found between different treatments in shoot nitrogen at 4 weeks, but these differences were no longer there at 6 and 8 weeks or at harvest Table-3. Thus, both inoculation and N-2 gave significantly higher N over that given by inoculation with the added P and inoculation with both P and N-1 (Tb and T1l respectively) at 4 weeks.

Shoot total N uptake (TN- uptake)

Data in Table-4 showed the TN uptake by soybean shoot. In general inoculated plants gave higher N uptake than uninoculated ones at all sampling dates irrespective of fertilizers added. In treatments 1, 2 and 3 increased N levels, obviously increased the amount of nitrogen taken up by the uninoculaed plants at. all sampling dates. Phosphorus addition also resulted in more N uptake, while added N-1 and N-2 brought about further increase in N uptake over that of P alone, (T4, T5 and T6). On the other hand, added N-2 to inoculated soybeans (T9) increased TN uptake significantly (p 0.05) over that of inoculated soybean + N-1 (T8) at 4 weeks, but no significant differences were observed at 6 and 8 weeks. Inoculation + P (Tb) increased TN-uptake insignificantly at 4 weeks over T4 (P). At 8 weeks this difference was doubled and was highly significant. Treatments 10, 11 and 12 although were not significantly different among themselves at 4, 6 and 8 weeks, but addition of N-1 or N-2 to (I + P) Tb, slightly increased the TN uptake at 4 and 8 weeks.

Table-3. Shoot nitrogen percentage as affected by different treatments.

Treatment		4 weeks after sowing S1	6 weeks after sowing S2	8 weeks after sowing S3	At harvest S 4
N %					
T1	Control	3.90 ab*	3.88 a	3.92 a	1.34 a
T2	N – 1	3.99 ab	3.91 a	3.93 a	1.43 a
T3	N – 2	4.11 a	3.93 a	4.01 a	1.42 a
T4	P	3.95 ab	3.88 a	3.81 a	1.25 a
T5	P + N – 1	4.03 ab	3.91 a	3.90 a	1.43 a
T6	P + N – 2	3.94 ab	3.91 a	3.97 a	1.39 a
T7	Inoculation	4.09 a	3.93 a	4.03 a	1.26 a
T8	I + N -1	3.93 ab	3.92 a	3.86 a	1.48 a
T9	I + N -2	3.96 ab	3.87 a	3.96 a	1.55 a
T10	I + P	3.82 b	3.80 a	3.92 a	1.52 a
T11	I + P + N -1	3.84 b	3.96 a	3.87 a	1.47 a
T12	I + P + N -2	4.01 ab	3.92 a	3.96 a	1.35 a
SE ±		0.067	0.047	0.65	0.10

* Duncan Multiple Range Test (DMRT): Means within the same column having common letters are not significantly different at 5% probability.

Table-4. Total N uptake by soybean shoot as influenced by different treatments (mg/ plant).

Treatment		4 weeks after sowing S1	6 weeks after sowing S2	8 weeks after sowing S3
mg/plant				
T1	Control	2.52 cd*	17.16 ab	28.52 c
T2	N – 1	2.88 bcd	16.33 ab	36.33 bc
T3	N – 2	3.78 abc	13.88 b	49.95 abc
T4	P	2.20 d	15.87 ab	36.64 bc
T5	P + N – 1	3.88 ab	16.19 ab	36.45 bc
T6	P + N – 2	3.24 abcd	23.01 ab	63.11 abc
T7	Inoculation	2.93 abcd	19.12 ab	49.29 abc
T8	I + N -1	2.78 bcd	24.98 ab	62.79 abc
T9	I + N -2	4.21 a	26.58 a	51.18 abc
T10	I + P	3.24 abcd	17.57 ab	79.16 a
T11	I + P + N -1	3.10 abcd	22.12 ab	74.26 ab
T12	I + P + N -2	3.08 abcd	25.02 ab	56.28 abc
SE ±		0.40	3.36	11.70

* DMRT: Means within the same column having common letters are not significantly different at 0.05 level.

Seed yield

In general, inoculated treatments with N or P or NP outyielded the noninoculated ones with N or P or NP significantly (Table-7). Inoculation alone significantly (P = 0.05) increased soybean seed yield over that the control (Ti) and yielded approximately the same seed yield as that of uninoculated soybeans + N-2 (T3) and T9 (I + N-2). Inoculation plus 50 kg N/ha (T6) significantly increased seed yield over that of inoculation plus 100 kg N/ha (T7) and gave seed yields which were not significantly different from that of T10 and T11 (I + P, I + P + N-1 respectively). Adding P or 50 kg N/ha or both P and N-1 combined to

ARPN Journal of Agricultural and Biological Science

inoculated soybeans increased seed yield significantly (P = 0.05) over all other treatments. Adding 100 kg N/ha (T3) increased seed yield significantly above all the uninoculated treatments. The latter were not significantly different among themselves.

100 seed weight

Inoculation generally increased the 100 seed weight compared to uninoculation (Table 8) and

Inoculation alone T7 or inoculation + N-2 (T9) gave significantly higher 100 seed weight than all the other treatments, whereas N-2 without inoculation (T3) gave the lowest 100 seed weight.

Table-5. ** Seed yield of soybean as influenced by different treatments (tons/ha)

Treatments		**Mean seed yield** (tons/ha)
T1	Control	1.296 c*
T2	N – 1	1.458 c
T3	N – 2	1.940 b
T4	P	1.458 c
T5	P + N – 1	1.090 c
T6	P + N – 2	1.222 c
T7	Inoculation	1.917 b
T8	I + N -1	2.569 a
T9	I + N -2	1.875 b
T10	I + P	2.611 a
T11	I + P + N -1	2.458 a
T12	I + P + N -2	1.972 b
SE $\pm$		0.137

** Yield determinations calculated per hectare were means of subplots. The area harvest per plot was 7.2 m^2.

*DMRT: Means having common letters are not significantly different at 0.05 level.

Table-6. 100 seed weight (gm) as affected by different treatments.

Treatments		**10 seed weight** (gm)
T1	Control	10.80 de*
T2	N – 1	10.18 de
T3	N – 2	9.40 e
T4	P	11.50 cde
T5	P + N – 1	100.75 de
T6	P + N – 2	11.00 de
T7	Inoculation	14.53 a
T8	I + N -1	13.13 bc
T9	I + N -2	15.75 a
T10	I + P	13.63 bc
T11	I + P + N -1	12.13 cd
T12	I + P + N -2	13.32 bc
SE $\pm$		0.68

*DMRT: Means having common letter (s) are not significantly different at 0.05 level.

Seed % N

Effects of' different treatments on seed % N are in Table-9. The control (TI) yielded the highest seed % N which was significantly higher than that of T2 (N-1), T4 (P), T5 (P + N-2), and Tl0 (I + P). Added N-1 or N-2 to inoculated treatments in the presence of phosphorus increased seed N very slightly and insignificantly over I + P (Tb, T1l and T12). Inoculated treatments were not significantly different among themselves.

Seed protein percentage (CP %)

Table-10 shows the effects of different treatments on soybean CP%. As expected effects of different treatments on CP % followed the same trend as for seed N %. The general differences between inoculated and uninoculated plants can be clearly seen. Data in Table (l0) showed the total protein yield per hectare (CP yield) as influenced by different treatments. Inoculation (T7) increased total protein by 0.26 ton over that of the control (T1). Added 50 kg N/ha to inoculated soybeans (TB) significantly increased total CP over inoculation plus 100 kg N/ha (T9) as shown in Figure-4b. Added 50 or 100 kg N/ha without inoculation increased total protein per hectare insignificantly above the control (T1).

ARPN Journal of Agricultural and Biological Science

Table-7. Soybean seed nitrogen percentage as influenced by different treatments.

Treatments		**Seed** (N%)
T1	Control	7.22 a*
T2	N – 1	6.85 b
T3	N – 2	6.90 ab
T4	P	6.76 b
T5	P + N – 1	6.77 b
T6	P + N – 2	6.92 ab
T7	Inoculation	5.90 ab
T8	I + N -1	7.00 ab
T9	I + N -2	6.91 ab
T10	I + P	6.80 b
T11	I + P + N -1	7.00 ab
T12	I + P + N -2	6.93 ab
SE ±		0.10

*DMRT: Means having common letters are not significantly different at 0.05 level.

Table-8. Soybean seed protein percentage as influenced by different treatments.

Treatments		**Protein percentage (%)**
T1	Control	45.17 a*
T2	N – 1	42.83 b
T3	N – 2	43.13 ab
T4	P	42.25 b
T5	P + N – 1	42.31 b
T6	P + N – 2	43.30 ab
T7	Inoculation	43.46 ab
T8	I + N -1	43.75 ab
T9	I + N -2	43.21 ab
T10	I + P	42.47 b
T11	I + P + N -1	43.80 ab
T12	I + P + N -2	43.34 ab
SE ±		0.62

*DMRT: Means having common letters are not significantly different at 5% probability level.

Table-9. Soybean total protein (T/ha) as influenced by different treatments.

Treatments		**Total Protein**
T1	Control	0.58 * defgh
T2	N – 1	0.62 defgh
T3	N – 2	0.83 abcdef
T4	P	0.62 defgh
T5	P + N – 1	0.46 h
T6	P + N – 2	0.53 efgh
T7	Inoculation	0.84 abcde
T8	I + N -1	1.13 a
T9	I + N -2	0.82 bcdefg
T10	I + P	1.11 ab
T11	I + P + N -1	1.08 abc
T12	I + P + N -2	0.86 abcd
SE ±		0.067

*DMRT: Means having common letters are not significantly different at 5% probability level.

Phosphorus addition to uninculated soybean plants slightly increased total CP (7%) over that ofT1 (Control), T5 (P + N-1) and T6 (P+ N-1) but not significantly. Treatment 10 (I + P) significantly (P =0.05) increased total CP/ha over that of the noninoculated control. Treatment 11 (I + P + N -1) and T12 (I + P + N – 2) significantly (P = 0.05) increased CP over T4 and T5 (P + N - 1 and P + N-2 respectively). Addition of 100 kg N/ha (T3) gave the same amount of CP as that of inoculation plus 100 kg N/ha (T9).

DISCUSSIONS

Inoculation with composite strains of *Rhizobium japonicum* showed some advantages over using single strains as most of the parameters studied showed the superiority of the composite strains. This mighi be due to different activities and tolerance of the different strains to climatic and other cultural conditions. Elhassan [11] found that when equal proportions of competing strains were applied to cowpea seedlings, there was a general dominance of' one strain responsible for the nodules formed. In the field good nodulation was encountered with seed inoculation. It was not surprising to notice that increasing N level decreased nodule dry mass. The depressing effect of combined N on nodulation was recognized by many workers (Hinson, [12], Shibbies et al. [13] and Mukhtar and Abu Naib, [3] Yates and Eday [14] related the inhibitory effect of combined N on nodulation to the depressing effect of combined N on the nitrogenase enzyme. The negative effect of fertilizer N on nodule dry matter was greater in the early than in the late sampling denoting possible N2-fixatjon recovery after applied soil N depletion. Depletion of nitrate from the top 60 cm of the soil at about 6 weeks from sowing was the possible cause of the recovery of nitrogenase activity and the smaller differences in NDM as reported by Herrige *et al*. [15]. Applied P to inoculated soybeans enhanced nodulation. This result agreed with the findings of Tang [16] and FAO [17] Singleton *et al* [18] found that NDM and nitrogenase activities significantly increased with P additions. Increases in NDM resulting from addition of P to N-1 over that of P + N-2 might also reflect the depressing effect of high N level on N2-fixation. Smaller differences between the inoculated and noninoculated soybeans in shoot dry matter at the early sampling dates were probably due to low nodulation. Mukhtar and Abu Naib [3] reported that at 4 weeks from sowing, N in the cotyledons plus possible N levels in the soil could mask the effect of N2-fixed especially if we know that N2-fixation was still very low at that early stage of the seedling growth. The significantly higher shoot dry matter at 8 weeks given by the inoculated soybean treatments above the noninoculated ones might be due to the prolonged activity of root nitrogenase enzym relative to nitrate reductase enzyme system which might explain the superiority of nodulated plants in DM production during maturity. Similar results were reported by Khalifa [4]. Inoculation plus 50 kg N/ha significantly increased shoot DM above that of non-inoculated treatments with 50 kg N/ha at late sampling. This was because of the lower N-demand by the crop and the availability of some soil N earlier in the season. The Gezira soils contain around 600 ppm total P but available P is as low as 4 ppm (Said, [19] The addition of P, though reported to have given erratic and inconclusive results with most of the field crops, has shown possible response by soybean in this work, a fact that is also true for wheat as reported by Ageeb [120] rice as reported by Ghobrial [21] and faba beans as reported by Mukhtar and Nourai [22]. In spite of the positive P influence on shoot product ion, there was no positive P accumulation in the soybean tissue contrary to what was reported by Hanway and Webber [23]. Both nitrogen and P percentages tended to decrease in plant shoot as the season progressed. Hanway and Webber [23] found that % P and % N in all plant parts decreased as the plant age progressed except in the seeds. Bowmen [and Smith [23] stated that N and P move readily to other plant organs from leaves which have accumulated these nutrients. This movement may continue to young growing organs and the concentration in old leaves may fall to-deficient levels. Increments in total N uptake in inoculated soybean crops in comparison to noninoculated ones were mainly due to increases in shoot DM from the large plants resulting from inoculation rather than N concentration per gram plant weight. The fact that inoculation alone gave seed yields similar to those of 100 kg N/ha indicates very good N2-fixation by soybean crop. Such results were reported by Mukhtar and Abu Naib [3] however; the high volatili zation losses of urea nitrogen when added to the alkaline soils of Gezira might have exaggerated the apparent effect of inoculation when added N-2 is compared to fixed N2 without knowing the actual fertilizer use efficiency of the crop. Inoculation plus 50 kg N/ha gave seed yields which were significantly higher than those of inoculation plus 100 kg N/ha. This result could be explained in the light of the inhibition of the higher dose to N2-fixation compared to the lower N dose i.e. the overall effect of inoculation providing more N to the plant than the high dose of fertilizer N which on the one hand negate the inoculation effect and will not be available throughout the growth period for either being taken up by the plant and/or lost to the atmosphere. Although erratic and inconclusive results were obtained from additions of 50 and 100 kg P205/ha to inoculated soybeans (cultivar Semmes) (Mukhtarand Abu Naib,[3] in this study inoculated soybeans (cv. Davis) yield was increased significantly by the addition of 50 kg P205/ha. Nitrogen fixation and yield of inoculated faba bean was enhanced by the addition of 50 kg P205/ha as reported by Mukhtar and Nourai [21] at Wad Medani and Turabi in the Gezira and at Rubatab in the Nile Province. This increase in seed yield of inoculated soybean was probably due to the effect of phosphorus on N2-fixation since the increase in seed yield of the noninoculated soybeans with 50 kg P205 were comparatively small. Smaller effects of P fertilization on soybean were reported by Hanway and webber [22]. Inoculated soybeans accumulated more shoot dry matter than that of noninoculated. Shibbles *et al*. [13] confirmed that carbohydrates accumulating in leaves prior to seed development are later utilized in seed growth. Increments in 100 seed weight of inoculated soybeans over the noninoculated, therefore, might be due to comparatively higher amount of carbohydrates stored and then utilized in seed growth.Modern cultivars contain about 41 % protein as reported by Shibbles *et al.* [13] Crude protein percentages of cultivars Davis and Jupiter ranged from 42 to 45% and from 36 to 38 % respectively which were higher than those of cultivar Semmes (24 %) as reported by Mukhtar and Abu Naib [3]. Although the control gave the highest CP % inoculation alone or the addition of N at both levels to inoculated and uninoculated treatments gave higher seed yields that resulted from the later treatments compared to that of the control.

CONCLUSIONS

a) The introduced peat inoculant gave good nodulatjon and N2-fjxation under field conditions. Thus proving its superiority over locally prepared Nile silt carrier.

b) Significantly higher shoot dry matter, total nitrogen uptake,100 seed weight, seed yield and total crude protein per hectare were obtained from seed inoculation of soybean in comparison with uninoculate ones under irrigation in Gezira Research Farm.

c) Similar yields were obtained from seed inoculation and from the application of 100 kg N/ha, which did not only indicate good nitrogen fixation by soybean (Cultivar Davis) under Gezira conditions, but also indicated that a good soybean crop can be produced without the application of chemical fertilizers.

d) The significantly higher seed yields obtained in inoculated treatments to which 50 kg N/ha were added over those with 100 kg N/ha confirmed previous findings that high N doses inhibit nodulatjon and nitrogen fixation.

e) The application of 50 kg N/ha to inoculated soybeans significantly increased nodule dry mass, shoot dry matter and seed yield.

f) The application of 50 kg P_2O_2 to inoculated soybeans significantly increased the nodule dry mass, shoot dry matter and seed yield.

LITERATURE CITED

[1] Bell R. E. 1979. Soybean in world trade. World soybean conference 11. Proceeding. Ed: frederich T. Corbin. pp. 736-766.

[2] Tadyoshi Masuda and Peter D. Goldsmith. 2009. World soybean Production: Area harvested Yield and long-term Projection. International food and Agribusiness Management review. 12(4).

[3] Mukhtar N. O. and Abu Naib S. A. 1987. Inoculation of irrigated soybean in the Sudan Gezira. J. Agric. Sci., Camb. 108: 183-187.

[4] Khalifa F. M. 1987. Effect of nitrogen on nodulation and yield of soybean under two systems of production in the Soudan. J.Agric. Science., Camb. 108: 259-265.

[5] Hittle C. N. 1974. Soybean around the world In: soybean production utilization. Ed: D.K. Whigham. INTSOYseries No.6.

[6] Subba Rao N. S. 1979. Crop responses to microbial inoculation. Recent advances in biological nitrogen fixation. ED: Subba Rao. New Delhi, India. pp: 406-420.

[7] Somasegaran P. and Hoben, H. J. 1985. Methods in legume Rhizobium technology.

[8] Said M. B. 1973. Ammonium fixation in the Sudan Gezira soil. Plant and soil.38:9-16.

[9] Mitchell H.L. 1972. Microdetermination of nitrogen in plant tissues J. of AOAC. 55: 1-3.

[10] Jackson J. E. 1962. Soil chemical analysis.

[11] Alhassan G. A. 1985. Competition of cowpea rhizobia inoculants in vitro and in soil Ph.D. dissertation, University of California Riverside.

[12] Hinson K. 1975. Nodulation responses from nitrogen applied to soybean half- root system. Agron. J.6:799-804.

[13] Shibbles R. M. *et al*. 1980. Soybean. Crop physiology. ED: L. T. E van. Cambridge University press Cambridge, London. pp. 151-189.

[14] Yates M. G. and Eday R. R. 1979. The physiology and regulation of nitrogen fixation. Recent advances in nitrogen fixation. Ed: N. S, New Delhi, India. pp. 88-113.

[15] Heridage *et al*. 1984. Effect of rihzobia on soil nitrate on the establishment and functioning of soybean symbiosis in field. Soybean abstracts. Vol. 7.

[16] Tang s. D. 1981. Study ofnodulation and nitrogenfixation of soybeans in soils. Soybean abstracts. 4: 167.

[17] FAO. 1984. Legume inocultaion and their use. Appocet manual jointly prepared by (NITAL) project, U. S. A. and FAO, Ronme.

[18] Singletan P. W., *et al*. 1985. Effect of phosphorus on the effectiveness of strains of R. japonicum. Soil Sci. Soci. Of Ameri. Jour. 49: 613-616.

[19] Said M.B. 1975. Distribution of phosphorus of the Sudan Gezira. Tropical agriculture. 52: 269-274.

[20] Ageeb O.A.A., Wheat. 1979. Annual report of the Gezira researches station and substation. pp. 17-20.

[21] Ghobrial G.I. 1987. Rice Agronomy. Annual report of the Gezira research station and substations. pp. 2-16.

[22] Mukhtar N.O. and Nourai A. 1986. Report of sixth Annual coordination meeting ICARDA / IFAD Nile valley project on faba bean, Cairo, Egypt. Pp43-50.

[23] Hanway J. J. and Webber C. R. 1971b. Dry matter accumulation in sonybean (Glycine max) (L). Marill). varieties. Agro. J. 63: 227-229.