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RESPONSE OF SOYBEAN TO DIFFERENT SYSTEMS OF IRRIGATION, PLANT DENSITY AND BIOLOGICAL-MINERAL NITROGEN FERTILIZATION UNDER RECLAIMED SANDY SOIL CONDITIONS IN WEST DELTA

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ABSTRACT

Response of soybean to different irrigation patterns; *i.e.*: furrow, drip and gun methods, planting distances, *i.e.*, 15 and 20 cm between the hills on ridges 60 cm apart, which produced 186 and 140 thousand plant/fed, respectively and biological mineral nitrogen fertilization (20 kg N/fed, 40 kg N/fed, bacteria inoculation, bacterial inoculation + 20 kg N/fed. and bacterial inoculation + 40 kg N /fed.), was investigated at Wady-Elnatron area, West Delta, El-Beheira Governorate, in moderately saline sandy soil high in pH value (8.2) during 2002 and 2003 summer seasons.

The highest seed yield per unit area was obtained by using drip irrigation system followed by gun method (1.44 and 1.24 ton/fed. respectively) while the lowest seed yield was obtained by using conventional furrow method (1.22 ton/fed.).

Maximum seed yield/fed was obtained with sowing distance of 15 cm between hills, (186000 plant/fed.), while most of the studied traits were higher with the lowest plant density (140000 plant/fed. produced from planting distance at 20 cm between hills) compared to the highest density.

Bacterial inoculation + 20 Kg N/fed gave the best results and the highest values of seed yield/fed. and yield components, oil yield/fed. and protein yield/fed compared with the other treatments, while the

lowest values were obtained from the 20 kg N/fed. treatment only.

The interaction between irrigation systems and plant density had significant effect on seed yield/fed and most of its components. The highest seed yield/fed. was produced by drip irrigation and high plant density (186000 plant/fed). Also the highest seed yield was obtained from using drip irrigation and fertilizing pattern (inoculation + 20 kg N/fed). On the other hand drip irrigation had the lowest costs and water quantity compared to other systems. As for water use efficiency, it is also obvious that drip irrigation gave the best results.

Therefore, drip irrigation, planting at 15 cm distance between hills (186000 plant/fed), adding 20 kg N/fed and seed inoculation with bacteria are recommended to improve soybean productivity in the newly reclaimed sandy soil under West Delta conditions.

Key words: *irrigation systems, plant density and biological mineral nitrogen fertilization, soybean.*

1. INTRODUCTION

Legume crops occupy an important position among field crops. Soybean is considered a relatively new crop in Egyptian rotation. Soybean is one of the legume crops with high protein and oil content in the seed which reach approximately 40% and 20%, respectively. Improving soybean productivity can be achieved through optimizing cultural practices, controlling irrigation water using new irrigation systems, planting density and seed inoculation with Rhizobia bacteria specially in the newly cultivated soils. Reducing soil and plant pollution are among the most important agronomic practices enhancing soybean production.

In Egypt, as well as in other soybean countries, several workers investigated the effect of irrigation systems and irrigation regime to maximize the productivity of field crops with reducing consumed water for maintaing available irrigation water. El-Wakeel (1979), stated that the highest soybean seed yield was obtained when irrigation took place at 40% depletion of the available soil moisture. Also, Bassuny (1982) found that seed yield increased when irrigation took place at 40% depletion of the available soil moisture. On the other hand he stated that seed yield increased when irrigation was given at 7 day intervals throughout the growing season and the lowest seed yield was obtained with irrigation at three week intervals.

Lin *et al.* (1986) indicated that plant height and leaf area/plant at the seed-filling stage reached 38.9 cm and 790.5 cm^2, respectively with sprinkler irrigation, while they were 32.8 and 21.8 cm and 602.9 and 496.4 cm^2, by furrow-irrigation and flood irrigation respectively. Seed yield obtained with sprinkler irrigation, furrow irrigation and flood irrigation were 88.05, 51.70 and 43.75 g /m^2, respectively.

Seed yield and other argonomic characters of soybean were sensitive to timing and amount of water throughout the growing season (Kadhem *et al.*, 1985, Yousef, 1989. Bridge *et al.*, 1996, and Haikel and Bassal 1996).

Plant population density and distribution of plants play an important role in the productivity of soybean. A marked increase in plant height, the number of pods/plant, seed index and seed yield /plant was found by increasing planting densities from 70000 to 175000 plant/fed (El-Attar, 1992) from 105000 to 245000 plant/fed (Ali, 1993), from 167000 to 333000 plant/ha (Prasad *et al.*, 1993) and from 400000 to 800000 plant/ha (Abbas, 1993 and Abbas *et al.*, 1995). Individual plant characters were decreased, while seed oil and protein yields per unit area were increased with increasing plant density (El-Attar, 1992; Ali, 1993; Prasad *et al.*, 1993; Abbas *et al.* 1995 and Haikel and Bassal, 1996). Increasing plant density was associated with the increase in seed yield/fed (Abd El-Aal, 1979, Zaki, 1988 and Zeyada *et al.*, 1988). In addition. Sharief and El-Bially (1992), found that each increase in plant density from 70 to 140 thousand plant/fed was associated with the increase in seed yield/fed. Prasad *et al.*, (1993) showed that seed yield was the highest with 333 thousand plants/ha and decreased with the reduction in plant density below this level.

Using biological fertilizers became very important to reduce the environmental pollution as a result of using mineral nitrogen. Inoculation of seeds or soil with N_2-fixing bacteria could compensate about 40 % of plant requirements of mineral nitrogen. On the other hand, increasing soybean productivity by increasing chemical fertilizers may increase production costs, and environmental pollution. Many reports indicated that inoculation of seeds or seedlings of various C_3 and C_4 plants with N_2-fixing bacteria led to enhancement of plant growth and yield (Dobereiner and Day, 1975; Eid, 1982 and Pohlman and McColl, 1982).

Mineral nutrient deficiencies are major constraints limiting legume nitrogen fixation and yield (O'Hara *et al.*, 1988). Among the necessary nutrients is a preliminary nitrogen dose to enhance growth of nitrogen fixing bacteria. If these requirements are not met, nodule formation and function are both adversely affected (Van Schreven, 1958). Malik *et al.*, (1993) found that N_2-fixing bacteria produce plant growth hormones such as indole acetic acid, indole-3-buteric acid, indole-3-ethanole, indole-3- methanole, abcisic acid, several gibberellin and cytokinins. Esaad *et al.* (1997), reported that biofertilization could compensate for 30-40% of the recommended nitrogen, especially in virgin lands.

2. MATERIALS AND METHODS

The present investigation was carried out at Wady-Elnatron area during 2002 and 2003 summer seasons, El-Beheira Governorate to study the effect of irrigation through estimating water consumptive use and water use efficiency, plant density and biological and mineral nitrogen fertilization and their interaction on yield and its components of "Clark" soybean cultivar under conditions of new reclaimed sandy soil in West Delta. The purpose was to evaluate different irrigation systems (furrow, gun and drip). Each one of these systems was evaluted in a separate experiment which contained two plant densities (140000 and 186000 plant/fed.) resulting from sowing two plants per hill at 20 and 15 cm distance on both sides of the ridge, respectively. Five combinations from biological and chemical fertilization, *i.e.* 20 kg nitrogen /fed 40 kg N/fed, bacterial inoculation, bacterial inoculation+ 20 kg N /fed. and bacterial inoculation+ 40 kg N /fed. were applied. Soybean seeds were inoculated with an effective strain of *Bradyrizobium japonicum* immediately before sowing. A split plot design in strip form with three replicates was adopted for this investigation. The plot size was 21 m^2 consisting of 7 ridges 5 m long and 60 cm apart.

The soil texture of the experimental site was sandy, moderate in salt with high pH value (Table 1).

Sowing took place during the third week of May on both sides of the ridge in hills 15 and 20 cm. Thinning was done to secure two plants/hill at 20 days after sowing. Calcium super phosphate 15% P_2O_5 at the rate of 30 kg P_2O_5/fed and potassium sulphate (50% K_2O) at the rate of 50 kg/fed. were added during land preparation. Bacterial inoculation and nitrogen fertilizer in the form of ammonium nitrate (33.5% N) were distributed randomly in sub-sub plots. The other agricultural practices of soybean growing were done as recommended.

Table (1): Mechanical and chemical analyses of soil averaged over seasons.

Mechanical analysis		Chemical analysis	
Clay	5.2%	Available N ppm	35
Silt	10.6%	Available P ppm	6
Fine sand	47.2%	Available K ppm	50
Coarse sand	30.8%	pH	8.2
Organic matter	0.8%	E.C. (ds/m)	0.73
Calcium carbonate	5.4%		
Texture	Sandy		

N-according to Jackson (1967), P according to Olsen *et al.* (1954) and K according to Jackson (1967).

At harvest, twenty guarded plants were labeled in each experimental unit (plot) to estimate the following characters:

1- Plant height (cm).
2- Number of branches/plant.
3- Number of pods/plant.
4- 100-seed weight (g).
5- Seed yield /plant (g).
6- Number of plants at harvest
7- Seed yield /feddan (ton): Seed yield of the central five ridges in each plot was estimated and converted to tons /feddan.
8- Seed oil percentage: For the determination of seed oil percentage Soxhlet continuous extraction apparatus was used according to the method described in A.O.A.C. (1980).
9- Total nitrogen was estimated by using micro Kjeldahl method, as described by A.O. A.C. (1980). protein content in seeds was calculated by multiplying the total nitrogen % by a factor of 6.25.

Irrigation water requirement (m^3) was estimated in the different irrigation systems using:

a) Flow-meter
b) Discharge of dripper (4L/hour/drip), gun system (30 m^3/hour/gun) and furrow system (60 m^3/hour/pcv tube 4").

The data obtained were subjected to the proper statistical analysis as outlined by Gomez and Gomez (1984). The treatment means were compared using the new least significant difference (N-LSD) as the procedures outlined by Waller and Duncan (1969).

3. RESULTS AND DISCUSSION

3.1. Effect of irrigation systems

The data in Tables (2 and 3) show the effect of irrigation systems on growth, yield and its components of soybean during the two seasons. The results revealed that all estimated characters were significantly affected by irrigation systems, in both seasons except no. of branches/plant, leaf area/plant, 100-seed weight and seed yield /plant in one season only. Drip irrigation surpassed the other two irrigation systems (gun and furrow) in producing the highest seed yield/fed. which was reflected from its yield components. It is one of the last innovation for applying water and fertilizer through emitters fixed on proper distance on the lateral lines of the system (Bucks and Nakayane, 1980). The highest averages of all the characters studied were obtained with drip irrigation. Gun irrigation came in the second rank in this concern, while the values of aforementioned traits were lower when soybean plants were irrigated by furrow irrigation. Over both seasons, soybean seed yields were 1.22, 1.24 and 1.44 tons/fed when irrigation systems were furrow, gun and drip, respectively. These results are in agreement with those obtained by Bakr *et al.* (1979) and Haikel and Bassal (1996) who mentioned that in sandy soil, trickle (drip) irrigation increased yield of soybean crop by 30% over furrow or sprinkler irrigation. Also, Abdel-Aziz *et al.* (1987) mentioned that the highest yield of fresh root and sucrose content of sugarbeet was obtained with using the drip irrigation system compared to other systems. The increase in seed yield under both drip and gun irrigation systems is mainly due to enough existence soil moisture in the root zone and continuous water supply at the different growth stages. In addition, fertilizers are not lost through deep percolation of irrigation water and maintaining high nutrient concentration in the root zone. Also, slow discharge rate of the drippers causes better aeration in the root zone. These results are in line with those obtained by Bridge *et al.* (1976), El-Wakeel (1979), Bassuny (1982) and Lin *et al.* (1986).

Table (2): Effect of irrigation systems, plant density and biological-mineral nitrogen fertilization on growth, yield and yield components of soybean in the two seasons.

Characters Treatments	Plant height (cm)		No. of branches /plant		No. of pods plant		Leaf area/plant (cm^2)	
	2002	2003	2002	2003	2002	2003	2002	2003
A-Irrigation systems:								
Furrow	61.80	66.72	3.71	4.28	17.51	18.51	60.40	67.08
Drip	67.95	74.24	4.28	4.23	19.9	21.61	67.11	67.61
Gun	67.0	71.36	4.00	4.02	19.67	20.58	64.65	67.55
F-Test	**	**	*	NS	**	**	**	NS
N-LSD (0.05)	1.23	1.18	0.39	---	0.51	0.68	1.61	---
(0.01)	1.87	1.78	---	---	0.77	1.04	2.44	---
B- Plant densities:								
15cm(186000P	71.43	76.09	3.58	3.70	17.00	17.39	57.97	62.55
l./fed.)	59.73	65.47	4.41	4.65	21.04	23.18	70.13	72.28
20cm(140000P	**	**	**	**	**	**	**	**
l./fed.)	1.10	1.20	0.40	0.31	0.55	0.71	0.01	1.28
F-Test	1.80	1.60	0.60	0.50	0.60	0.83	1.38	1.42
N-LSD (0.05)								
(0.01)								
C-Biological-mineral fertilization:								
20 kg N/fed	57.84	63.54	3.20	3.37	15.89	[illegible]	56.07	58.86
40 kg N/fed	63.78	68.45	3.93	4.00	18.26	[illegible]	62.81	67.48
Inoculation	66.47	71.84	4.00	4.20	19.48	20.78	65.22	68.31
Inocul.+20 kg	70.38	75.69	4.44	4.71	21.00	22.70	68.28	71.43
N/fed	69.42	74.37	4.39	4.61	20.49	21.68	67.96	70.98
Inocul.+40 kg	**	**	**	**	**	**	**	**
N/fed	[illegible]	1.50	0.39	0.29	0.56	0.66	1.05	1.38
F-Test	2.62	2.07	0.54	0.40	0.77	0.91	1.45	[illegible]
N-LSD (0.05)								
(0.01)								
Interaction:								
A x B	NS	**	NS	*	NS	*	NS	NS
A x C	NS	NS	NS	NS	NS	NS	**	*
B x C	*	*	**	**	**	**	NS	**
A x B x C	NS	*	NS	*	NS	NS	**	NS

Table (3): Effect of irrigation systems, plant density and biological-mineral nitrogen fertilization on growth, yield and yield components of soybean in the two seasons.

Characters / Treatments	100-seed weight (g)		Seed yield /plant (g)		No. of plants at harvest (1000 plant)		Seed yield (ton/fed)		Oil yield (kg/fed)		Protein yield (kg/fed)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
A-Irrigation systems:												
Furrow	14.80	15.32	9.08	9.39	144.06	151.06	1.19	1.24	225.03	214.81	365.10	421.18
Drip	15.70	15.48	9.37	11.04	158.47	164.83	1.26	1.61	260.72	253.23	438.25	515.0
Gun	14.85	15.47	9.31	9.77	150.33	151.99	1.20	1.27	236.41	229.22	401.2	442.35
F-Test	*	NS	NS	**	**	**	*	**	**	**	**	**
N-LSD (0.05)	0.64	—	—	0.20	5.61	6.21	0.04	0.04	19.81	16.72	32.13	38.11
(0.01)	—	—	—	0.30	7.31	8.38	—	0.07	22.35	18.89	37.41	43.02
B- Plant densities:												
15cm(186000 Pl./fed.)	13.74	14.35	8.13	8.57	166.20	173.53	1.23	1.41	257.25	251.30	501.82	533.8
20cm(140000 Pl./fed.)	16.49	16.50	10.38	11.56	135.71	138.40	1.20	1.34	224.20	213.52	301.50	385. 20
F-Test	**	**	**	**	**	**	**	**	**	**	**	**
N-LSD (0.05)	0.56	0.33	0.35	0.23	6.45	6.98	0.04	0.07	18.61	18.1	35.00	40.00
(0.01)	0.66	0.42	0.46	0.31	8.20	8.86	0.06	0.08	22.32	21.6	40.00	46.00
C-Biological-mineral fertilization:												
20 kg N/fed	12.66	13.28	7.79	8.50	130.53	146.71	0.90	1.06	223.26	220.01	290.12	339.25
40 kg N/fed	14.79	15.26	8.91	9.79	154.43	157.87	1.17	1.34	228.23	225.03	363.22	392.00
Inoculation	15.66	15.68	9.44	10.03	153.47	154.60	1.26	1.36	239.72	230.02	398.00	450.38
Inocul.+20 kg N/fed	16.33	16.50	10.17	11.08	162.66	164.35	1.40	1.58	261.50	247.01	498.11	565.62
Inocul.+40 kg N/fed	16.14	16.39	9.95	10.92	153.68	156.27	1.35	1.51	250.91	240.03	458.12	550.22
F-Test	**	**	**	**	**	**	**	**	**	**	**	**
N-LSD (0.05)	0.43	0.38	0.36	0.28	4.31	5.98	0.04	0.06	21.36	16.25	160.28	182.18
(0.01)	0.60	0.53	0.50	0.39	5.61	6.41	0.06	0.08	24.10	18.34	180.84	205.61
D- Interaction:												
A x B	NS	NS	NS	**	NS	*	NS	**	NS	**	NS	*
A x C	NS	*	*	**	*	*	NS	*	*	*	*	*
B x C	**	**	**	**	NS	NS	**	**	**	**	*	**
A x B x C	*	**	NS	NS	NS	NS	NS	**	NS	**	NS	*

3.1.1. Water requirements and costs

It is quite clear from the data listed in Table (4) that water quantity in the whole season was less under drip irrigation (3160 m^3) compared to gun system (5400 m^3) and furrow one (7200 m^3). The results in Table (5) show that drip irrigation gave the least costs compared to the other methods. Cost per ton of seed yield was 240.9, 479.0 and 649.2 L.E. for drip, gun and furrow irrigation systems, respectively. As for water use efficiency (WUE) among the studied methods, it is obvious that the drip system gave the best results (Table 5). Compared to the basic values 100 of WUE for the furrow irrigation system, relative values were 270.6 and 135.3 for drip and gun systems, respectively.

3.2. Effect of plant density

Planting distances had significant effects on all estimated characters in both seasons (Tables 2 and 3). Increasing plant density from 140000 (20 cm among the hills) to 186000 plant/fed (15 cm between hills) decreased the number of branches/plant, the number of pods/plant, leaf area /plant, 100-seed weight and seed yield/plant except plant height, the number of plants at harvest, oil and protein yield and seed yield/fed. Increasing plant height with increasing plant density may be due to increasing competition for light due to dense planting. Similar observations were reported by Abd El-Aal (1979) and Sharief and El-Bially (1992). Seed yield /fed reached its maximum with sowing 186000 plant/fed and this may be gained due to the great amount of light energy intercepted by the canopy per unit area. It is important to explain that for low density all the characters (except plant height, oil and protein yields kg/fed and seed yield/fed) were in higher value because the low number of the plants per unit area had a bigger chance to get more light and different nutrients and elements, but the increase in seed yield /fed in dense planting is mainly attributed to the increase in the number of plants/unit area. These results are in line with those obtained by Zeyada *et al.* (1988), Mohamed (1991), Abbas (1993), Haikel and Bassal (1996) and Salem *et al.* (2000).

Table (4): Irrigation water requirements and irrigation costs for soybean over two seasons.

	Irrigation systems		
Water requirements and costs	**Drip**	**Gun**	**Furrow**
1- Water quantity/hours/fed (m^3)	56.0	60.0	60.0
2- Time of irrigation/fed/day (hour)	0.50	1.50	2.00
3- Water requirements/irrig./day (m^3) (1 x 2)	28.0	90.0	120.0
4- Number of irrig./fed/season.	120.0*	60.0**	60.0**
5- Water quantity/seasons (m^3/fed). (3 x 4)	3160.0	5400.0	7200.0
6-Cost of one m^3 of water (L.E).	0.11	0.11	0.11
7- Cost of irrig. of whole season (L.E.) (5 x 6).	347.6	594.0	792.0

* Irrigation every day, ** irrigation day after day.

Table (5): Comparative yield and water use efficiency among irrigation systems (average of two seasons).

	Irrigation systems		
Water requirements and costs	**Drip**	**Gun**	**Furrow**
1- Seed yield (ton/fed)*	1.44	1.24	1.22
2- Cost of irrig./seasons (L.E)*	347.6	594.0	792.0
3- Cost of irrig./ton (L.E).	240.9	479.0	649.2
4- Water use efficiency (WUE)(kg/m^3)**	0.46	0.23	0.17
5- Relative amount WUE.	270.6	135.3	100.0

* El-Buhaira governorate

$$** \ WUE = \frac{\text{Grain yield (kg)}}{\text{Amount of irrigation water } (m^3)}$$ (Plaut *et al.*, 1988)

3.3. Biological-mineral nitrogen fertilization

Several investigators reported that nitrogen fertilization caused additional increase in growth and yield (Tiwari *et al.*, 1991). To reduce the environmental pollution resulting from using more of mineral nitrogen, inoculation of the soil or the seeds with bacteria helps to avoid the environmental contamination. The results obtained in this study (Tables 2 and 3) showed that all the characters under study were significantly affected with increasing doses of nitrogen + biofertilizer up to seed inoculation + 20 kg N/fed which resulted in the maximum seed yield, oil yield and protein yield/fed, *i.e.*, 1.49 ton/fed, 254.3 kg/fed and 531.9 kg /fed, respectively over two seasons, while inoculation + 40 kg N/fed inhibited activity of bacteria and gave lower values comparing to seed inoculation + 20 kg N/fed. This means that the low nitrogen dose of 20 kg N/fed enhanced bacteria to fix nitrogen. These results agree with the results of Abd El-All *et al.*, 1996; and Esaad *et al.* (1997). Biofertilizers saved about 40 kg N/fed where the treatment 40 kg N/fed gave seed yield 1.23 ton/fed over two seasons and the treatment of inoculation with bacteria only gave seed yield/fed of 1.31 ton. These results confirm the findings of Ishak *et al.* (1993) and El-Aggory *et al.* (1996). The newly reclaimed soils are poor in its nitrogen content and requirement of soybean to nitrogen is more than 60.0 kg N/fed. in this type of soil. The addition of 20.0 kg N/fed. and inoculate the soil with bacteria is enough dose to cover the requirement of soybean from nitrogen. In case of successful bacterial inoculation, also this help to reduce the nitrogenous pollution.

3.4.Interaction effects

The interaction between irrigation systems and plant density significantly affected plant height, no. of branches/plant, no. of pods/plant, seed yield/plant, no. of plants at harvest, seed yield/fed, oil yield/fed and protein yield/fed (Tables 2 and 3) in one season only. The highest value of seed yield 1.51 ton/fed. was produced by drip irrigation with plant population 186000 plants/fed., *i.e.* 15 cm between the hills (Table 6).

The interaction between irrigation systems and biological-mineral nitrogen fertilization had marked effects on leaf area /plant, seed yield/plant, no. of plants at harvest, seed yield/fed, oil yield/fed and protein yield/fed. (Tables 2 and 3). The highest values of the previous mentioned traits were produced from drip irrigation and biological fertilize + 20 kg N/fed. The highest value of seed yield (1.83 ton/fed.) was obtained through drip irrigation and 20 kg N/fed inoculated seed with *Bradyizobium japonicium* bacteria, treatment (Table 7).

Concerning plant density x biological-mineral nitrogen fertilization interaction, the maximum seed yield (1.7 ton/fed) was obtained when 15 cm between hills and 20 kg N/fed + inoculated seed treatment were applied (Table 8).

Table (6): Average soybean seed yield (ton/fed) as affected by the interaction between irrigation systems and plant density in the second season.

Irrigation systems	Plant density	
	15 cm	20 cm
Furrow	1.40	1.10
Drip	1.71	1.31
Gun	1.52	1.20
F-Test	**	
N-LSD (0.05)	0.06	
(0.01)	0.10	

Table (7): Average soybean seed yield (ton/fed) as affected by the interaction between irrigation systems and biological-mineral nitrogen fertilization in the second season.

Irrigation systems	Biological-mineral nitrogen fertilization				
	1	2	3	4	5
Furrow	0.94	1.29	1.31	1.41	1.36
Drip	1.27	1.50	1.59	1.83	1.79
Gun	0.98	1.23	1.27	1.43	1.40
F-Test	*				
N-LSD (0.05)	0.10				
(0.01)	---				

The interaction between plant density and biological-mineral nitrogen fertilization had significant effect on plant height, no. of branches/plant, no. of pods/plant, 100-seed weight, seed yield/plant, seed yield/fed, oil yield /fed and protein yield/fed (Tables 2 and 3).

Table (8):Average soybean seed yield (ton/fed) as affected by the interaction between plant densities and biological-mineral nitrogen fertilization in the two seasons.

Plant densities	Biological-mineral nitrogen fertilization									
	2002					2003				
	1	2	3	4	5	1	2	3	4	5
15 cm (186000 Pl./fed.)	1.35	1.45	1.44	1.55	1.42	1.56	1.60	1.65	1.85	1.66
20 cm (140000 Pl./fed.)	0.46	0.78	1.08	1.27	1.37	0.76	0.97	1.19	1.43	1.06
F-Test	**					**				
N-LSD (0.05)	0.06					0.06				
(0.01)	0.09					0.09				

1. 20 kg N/fed 2. 40 kg N/fed 3. Inoculation
4. Inocul. + 20 kg N/fed 5. Inocul. + 40 kg N/fed

Table (9): Average soybean seed yield (ton/fed) as affected by the interaction among irrigation systems, plant densities and biological-mineral nitrogen fertilization in the second season.

Irrigation systems	Plant density	Biological-mineral nitrogen fertilization				
		1	2	3	4	5
Furrow	140.000 plants/fed.	0.62	1.00	1.20	1.36	1.41
	186.000 plants/fed.	1.41	1.58	1.42	1.44	1.43
Drip	140.000 plants/fed.	0.73	1.05	1.08	1.23	1.41
	186.000 plants/fed.	1.92	1.42	1.48	1.96	1.44
Gun	140.000 plants/fed.	0.55	0.86	1.29	1.71	1.87
	186.000 plants/fed.	1.37	1.59	1.68	1.81	1.92
F-test				**		
N.LSD(0.05)				0.11		
(0.01				0.15		

The interaction among irrigation method, plant population and biological-mineral nitrogen fertilization had marked effects on plant height, no. of branches/plant, leaf area/plant, 100-seed weight, seed yield/fed, oil yield/fed and protein yield/fed. The highest value of seed yield (1.96 ton/fed.) was obtained from drip irrigation with plant population 186000 plants/fed. and biological fertilizer + 20 kg N/fed. (Table 9).

From these results, the recommendation could be reached that the highest seed yield/fed can obtained when using drip irrigation system, 186000 plants per feddan and fertilization with 20 kg nitrogen per feddan + seed inoculation with bacteria under reclaimed sandy soil conditions in west Delta.

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استجابة فول الصويا لنظم مختلفة من الري والكثافة النباتية والتسميد النتروجينى الحيوي والمعدني تحت ظروف الأراضي الرملية حديثة الإستصلاح فى غرب الدلتا

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ملخـــص

درست استجابة محصول فول الصويا لطرق مختلفة من الري وهى الــري بالغمر وبالتنقيط والري المدفعي (كأحد نظم الري بالرش). كانت مسافات الزراعة ١٥، ٢٠ سم بين الجور مع ترك نباتين بالجوره ، ٦٠ بين الخطوط وعلى جــانبي الخط والتي أعطت كثافة نباتية ١٨٦، ١٤٠ ألف نبات بالفدان على التوالي. كــان التسميد النيتروجيني المعدني والحيوي بمعدل ٢٠ ، ٤٠ كجــم نتــروجين معــدني /فدان، تسميد حيوي بكتيري فقط، تسميد حيوي بكتيري + ٢٠ كجم نتروجين/فدان، تسميد حيوي بكتيري +٤٠ كجم نتروجين/فدان. أقيمت التجربة فى عامي ٢٠٠٢ ، ٢٠٠٣ فى منطقة وادى النطرون محافظة البحيرة غرب الدلتا حيث التربة رمليـــة ومعتدلة فى نسبة الأملاح ..ا وإن كانت عالية نسبيا فى رقم الـــ pH (٨,٢).

ـ أمكن الوصول إلى أعلى محصول باستخدام نظام الرى بالتنقيط ١,٤٤ طن/فــدان يليه الرى بالرش ١,٢٤ طن/فدان وكان أقل محصول من الرى بالغمر حيث كــان ١,٢٢ طن للفدان.

- كان أعلى محصول للبذور للفدان الناتج من زراعة نباتات فول الصويا على مسافة ١٥ سم بين الجور (١٨٦ ألف نبات للفدان). ولو أن معظم الصفات المدروسة كانت أعلى عند الزراعة على مسافة ٢٠ سم بين الجور (١٤٠ ألف نبات للفدان).
- أعطت المعاملة باللقاح البكتيري + ٢٠ كجم نيتروجين للفدان أعلى محصول للفدان سواء من البذرة، الزيت أو البروتين بينما أقل كمية من الصفات التي تحت الدراسة تم الحصول عليها من التسميد النيتروجيني المعدني بمعدل ٢٠ كيلو جرام نيتروجين بالفدان.
- أدى استخدام الري بالتنقيط إلى تقليل تكلفة الري وتقليل استخدام مياه الري يليهـا الري المدفعي بينما كانت أعلى تكلفة وأعلى كمية من الميـاه المسـتهلكة بـالري بالغمر.

وتوصي الدراسة للحصول على أفضل محصول للبذور من فول الصويا إلى استخدام نظام الري بالتنقيط والزراعة على مسافة ١٥ سم بين الجور و ٦٠ سم بين الخطوط على جانبي الخط مع خف النباتات على نباتين بالجورة وأعطى ذلك كثافة نباتية ١٨٦ ألف نبات في الفدان والتسميد بمعدل ٢٠ كجم نيتروجين مـع التلقـيح البكتيري وذلك في الأراضي الرملية الحديثة الإصلاح في غرب الدلتا.

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