RESULTS AND DISCUSSION

First Experiment:

The first experiment in this work included 35 treatments which were the combinations of 7 irrigation treatments (normal irrigation, skipping 3rd + 4th irrigations, skipping 3rd + 5th irrigations, skipping 3rd + 6th irrigations, skipping 4th + 5th irrigations, skipping 4th + 6th irrigations and skipping 5th + 6th irrigations) and 5 levels of nitrogen fertilizer (0, 15, 30, 45 and 60 kg N/fed.).

I- Effect of irrigation treatments:

A) Growth characters:

1. Plant height:

Data in Table (6) shows the effect of irrigation treatments on growth charaters of soybean plant after 90 days from planting as a combined analysis of 1991, 1992 and 1993 seasons.

Irrigation treatments affected significantly all growth characters presented in Table (6).

Plant height decreased significantly by skipping 3rd + 4th, 3rd + 5th or 3rd + 6th irrigations as compared by normal irrigation. Plant height decreased by 12.01, 11.11 and 13.05 cm by skipping 3rd + 4th, 3rd + 5th or 3rd + 6th irrigations as compared with normal irrigation, respectively. The differences in plant height between the above three treatments were not significant. On the other hand, plant height decreased by skipping

Table (6): Effect of irrigation treatments on growth characters of soybean plants after 90 days from planting.

Combined analysis of 1991, 1992 and 1993 seasons

Irrigation treatments	Plant height cm	No. of branches/ plant	No. of leaves / plant	No. of pods/ plant	Leaf area/ plant cm^2	Leaf area index cm^2/cm^2	Fresh weight (g)				Dry weight (g)			
							Leaves	Stems	Pods	Total	Leaves	Stems	Pods	Total
Normal irrigation	83.19a	3.48b	18.35a	38.64a	1782.23ab	5.94ab	34.34ab	32.35ab	47.20ab	113.89b	12.47a	11.94a	15.13a	39.54a
Skipping 3rd+4th irrigations	71.18b	3.21b	18.35a	30.89b	1788.50ab	5.96ab	32.13b	28.21cd	38.48e	98.82d	10.53c	10.51bcd	12.48c	33.52d
Skipping 3rd+5th irrigations	72.08b	3.18b	17.24a	31.69b	1591.61c	5.30c	31.31b	27.01d	42.91cd	101.23d	10.90bc	9.96d	13.46bc	34.32cd
Skipping 3rd+6th irrigations	70.14b	3.23b	17.75a	32.77b	1613.06c	5.37c	32.37b	26.89d	40.78de	100.04d	11.45abc	10.08cd	13.34bc	34.87c
Skipping 4th+5th irrigations	81.50a	3.77a	18.87a	37.62a	1662.96bc	5.54bc	32.21b	31.10bc	43.98bc	107.29c	11.57abc	11.23abc	14.14ab	36.94b
Skipping 4th+6th irrigations	81.80a	3.47ab	19.43a	41.67a	1912.15a	6.37a	37.06a	34.68a	47.97a	119.71a	12.10ab	11.82ab	15.46a	39.38a
Skipping 5th+6th irrigations	81.83a	3.34b	19.44a	38.13a	1938.75a	6.46a	34.64ab	32.41ab	46.61ab	113.66b	11.75abc	11.31abc	15.38a	38.44a

4th + 5th, 4th + 6th or 5th + 6th irrigations as compared with control (normal irrigation) but the differences did not reach the 5% level of significance. Plant height reached its maximum peak (83.19 cm) by normal irrigation treatment. skipping any irrigation decreased plant height.

This result clears the essential role of water supply to plant height. Similar results on soybean were obtained by Kramer (1963), Lutz and Jones (1975), Sherif (1978), El-Wakeel (1979), Momen *et al.* (1979), Ali (1981), Rossine and Lin (1981), Badran (1986), Zaki (1988), Abo El-Kheir (1990), Ashoub *et al.* (1992) and Abo El-Kheir *et al.* (1993).

2. Number of branches per plant:

With regard to number of branches per plant, it is clear from Table (6) that the maximum number of branches of soybean plant was obtained by skipping 4th + 5th irrigations. The differences in number of branches between skipping 4th + 5th or 4th + 6th irrigations were not significant.

This result is in harmony with those obtained by Abo El-Kheir *et al.* (1993) on soybean, who found that decreasing amount of available water of the soil led to a progressive significant reduction in number of branches per plant.

3. Number of leaves per plant:

Irrigation treatments did not affect significantly number of leaves per soybean plant as shown in Table (6).

It could be concluded that exposing soybean plants to water stress via skipping two irrigations at different growth stages caused significant increase in the plant height as well as number of branches per soybean plant.

These results are in good agreement with those obtained by Ali (1981) on soybean, who indicated that the effect of irrigation intervals on number of leaves per soybean plant was not significant in the two seasons. He also found that missing 3rd, 4th or 5th irrigation decreased significantly number of leaves per plant, compared with other treatments. Similar results were obtained on soybean by Kassab (1993).

4. Number of pods per plant:

Number of pods per plant was significantly affected by irrigation treatments. There were no significant differences in number of pods per plant between normal irrigation (control) and skipping 4th + 5th, 4th + 6th or 5th + 6th irrigations, also between skipping 3rd + 4th, 3rd + 5th or 3rd + 6th irrigations. The reduction percentage in number of pods per plant were 20.05, 17.98, 15.19, 2.63 and 1.31% obtained by skipping 3rd + 4th, 3rd + 5th, 3rd + 6th, 4th + 5th or 5th + 6th irrigations, respectively as compared with the normal irrigation.

These results may be due to the abortion of some flowers as a resultant of the relationship between soil moisture stress via skipping two irrigations and different physiological processes occurred in plant. These results in harmony with those obtained

by Sionit and Kramer (1977), Sherif (1978), El-Wakeel (1979), Ali (1981), Weiss (1983) and Cox and Jolliff (1986). Kassab (1993) on soybean who found that irrigation regimes exhibited significant differences on number of pods per plant at 85 days after planting in the two seasons.

5. Leaf area and leaf area index:

Leaf area as well as leaf area index was affected by irrigation treatments (Table, 6). Leaf area and leaf area index decreased significantly by skipping 3rd + 5th or 3rd + 6th irrigations as compared with the control treatment. Skipping 3rd + 5th, 3rd + 6th and 4th + 5th irrigations as well as skipping 4th + 6th and 5th + 6th irrigations did not affect leaf area and leaf area index as shown in Table (6). Leaf area and leaf area index reached its maximum values by skipping 5th + 6th irrigations without any significant affect as compared with normal irrigation, whereas it reached its minimum values by skipping 3rd + 5th irrigations.

This result is expected since number of leaves per soybean plant increased by normal irrigation and skipping 3rd + 4th, 4th + 5th, 4th + 6th or 5th + 6th irrigations. Similar results were obtained by El-Wakeel (1979), Egli *et al.* (1983), Scott (1984), Calmes *et al.* (1985), Cox and Jolliff (1986), Abo El-Kheir (1990), Ashoub *et al.* (1992) and Abo El-Kheir *et al.* (1983).

6. Fresh weight:

Irrigation treatments affected significantly fresh weight of leaves, stems, pods and total fresh weight of soybean plant. Fresh

weight of leaves, stems and pods per plant increased significantly by normal irrigation and skipping 4th + 6th or 5th + 6th irrigations than that by other treatments. Fresh weight of leaves, stems and pods reached its minimum weight by skipping 3rd + 5th, 3rd + 6th and 3rd + 4th irrigations, respectively, on the other hand, it decreased by 3.03, 5.46 and 8.72 g as compared by normal irrigation for the same respective treatments.

Total fresh weight of soybean plant reached its maximum weight by skipping 4th+6th irrigations with a significant effect as compared with the other irrigation treatments, whereas it came to its minimum weight by skipping 3rd+4th irrigations.

7. Dry weight:

With regard to dry weights of leaves, stems, pods and total dry weight of soybean plant, data in Table (6) showed clearly that irrigation treatments affected them significantly. Dry weight increased by 1.94, 1.57 and 1.02 g/plant for leaves and 1.43, 1.98 and 1.86 g/plant for stems and 2.65, 1.67 and 1.79 g/plant for pods for normal irrigation as compared with skipping 3rd + 4th, 3rd + 5th and 3rd + 6th irrigations, respectively. Skipping 4th + 5th, 4th + 6th and 5th + 6th irrigations did not significantly affect dry weight of leaves, stems and pods as shown in Table (6). The total dry weight behaved the same trend of dry weight of leaves, stems and pods as shown in Table (6). Total dry weight of soybean plant increased by 6.02, 5.22 and 4.67 g for normal irrigation (control) as compared by skipping 3rd + 4th, 3rd + 5th and 3rd + 6th irrigations, respectively.

These results are in harmony with those obtained by Boerma and Ashley (1982) who found that the increase percentages of leaf + petiole, stem + branches and total vegetative weight of soybean plant as a result of irrigation were 52, 49 and 51% as compared with non-irrigated treatment. Abo El-Seud (1987) indicated that fresh weight of stressed soybean plant was remarkably depressed as compared to unstressed plants. Ashoub *et al.* (1992) reported that dry weight of leaves, stems and pods per plant were significantly decreased by exposing soybean plant to water lacking. Abo El-Kheir *et al.* (1993) concluded that decreasing the amount of available water of the soil led to a progressive significant reduction in dry weight of shoot of soybean plant.

It could be concluded that irrigation treatments affected significantly growth characters of soybean plant, skipping two irrigations at vegetative growth period (third and fourth irrigation) resulted to a decrease in plant height as well as fresh and dry weight of soybean plant. Furthermore, it was found that skipping the fifth and sixth irrigations did not affect significantly growth characters. This is to be expected since water supply is very essential to cell division as well as cell elongation at the vegetative growth period. The results suggest that the detrimental effect of skipping water at the vegetative growth period on growth characters surpassed that of exposing irrigation at the late growth period.

B- Yield and yield components:

Table (7) show the effect of irrigation treatments on number and weight of pods per plant, number of seeds per pod, weight of 100-seed yield of plant, seed yield and biological yields per fed. as combined analysis of 1991, 1992 and 1993 seasons.

Irrigation treatments affected significantly all yield and yield components estimated in our study except number of seeds per pod.

1. Number of pods per plant:

The number of pods per soybean plant increased significantly by normal irrigation than that other treatments except the siventh treatment. Skipping 3rd + 4th, 3rd + 5th, 3rd + 6th and 4th + 5th irrigation did not affect number of pods per plant. The number of pods per plant decreased by 7.82, 13.15, 9.96, 7.84 and 5.77% with skipping 3rd + 4th, 3rd + 5th, 3rd + 6th, 4th + 5th and 4th + 6th irrigations, respectively, as compared with the normal irrigation.

Similar results were obtained by Abdel-Gawad *et al.* (1983), Ramseur *et al.* (1984), Cox and Jolliff (1986), Sorour *et al.* (1988) and Abo El-Kheir *et al.* (1993).

2. Weight of pods per plant:

The effect of irrigation treatments on weight of pods per soybean plant was similar to that obtained on number of pods per

Table (7): Effect of irrigation treatments on yield and yield components of soybean plants at harvest time.

Combined analysis of 1991, 1992 and 1993 seasons

Irrigation treatments	No. of pods/ plant	Weight of pods/plant (g)	No. of seeds/pod	Weight of 100-seed (g)	Yield of plant (g)	Seed yield (kg/fed.)	Biological yield (kg/fed.)
Normal irrigation	56.49a	36.45a	2.85a	17.15a	20.04a	1025.76a	3854.55a
Skipping 3rd+4th irrigations	52.07bc	32.10bcd	2.88a	16.18bc	18.08bc	839.38e	3330.53c
Skipping 3rd+5th irrigations	49.06c	31.38d	2.83a	16.39bc	16.98c	867.43de	3048.51d
Skipping 3rd+6th irrigations	50.86bc	30.92d	2.86a	17.06a	17.79bc	910.88cd	3276.83c
Skipping 4th+5th irrigations	52.06bc	31.83cd	2.83a	15.89c	17.59bc	914.88cd	3458.76bc
Skipping 4th+6th irrigations	53.23b	34.29abc	2.84a	16.78ab	18.69bc	944.93bc	3397.71bc
Skipping 5th+6th irrigations	57.21a	34.54ab	2.86a	16.26bc	19.28ab	978.05ab	3574.16b

4. weight of 100-seed:

Irrigation treatments affected significantly weight of 100-seed as shown in Table (7). The highest values of 100-seed were obtained by normal irrigation and skipping 3rd + 6th or 4th + 6th irrigations comparing with other treatments. The decrease percentage in weight of 100-seed were 5.65, 4.43, 7.43 and 5.18% by skipping 3rd + 4th, 3rd + 5th, 4th + 5th and 5th + 6th irrigations respectively, as compared with control.

These results are in good agreement with those reported by Sherif (1978), Sorour *et al.* (1988) and Abdalla *et al.* (1992).

5. Weight of seeds per plant:

Seed yield per plant was affected significantly by irrigation treatments as shown in Table (7). Seed yield per plant reached its maximum value by normal irrigation. However, the difference of seed yield per plant was not significant between normal irrigation and skipping 5th + 6th irrigations. Increasing seed yield per plant by normal irrigation may be due to the increase in number and weight of pods per plant by normal irrigation than other treatments. It is clear from Table (7) that the effect of irrigation treatments on seed yield per plant was similar to that obtained on weight and number of pods per plant.

In this respect, Sherif (1978), El-Wakeel (1979), Nogueira *et al.* (1988). Sorour *et al.* (1988), Vieira *et al.* (1991) and Abo El-Kheir *et al.* (1993) concluded that weight of seeds per soybean plant was significantly decreased as soil moisture stress increased.

6. yield:

Irrigation treatments affected significantly seed yield of soybean per fed. as shown in Table (7). Seed yield increased significantly by normal irrigation and skipping 5th + 6th irrigations than other treatments. Seed yield reached its maximum weight by normal irrigation treatment, whereas, it reached its minimum weight by skipping 3rd + 4th irrigations treatment. The differences of seed yield (kg/fed.) between skipping 3rd + 5th, 3rd + 6th and 4th + 5th irrigations were not significant. Seed yield could be arranged in descending order according to irrigation treatments as follows: normal irrigation, skipping 5th + 6th, 4th + 6th, 4th + 5th, 3rd + 6th, 3rd + 5th and 3rd + 4th irrigations, respectively. The decreases percentage in seed yield of soybean per fed. were 18.16, 15.43, 11.19, 10.80, 7.88 and 4.65% by skipping 3rd + 4th, 3rd + 5th, 3rd + 6th, 4th + 5th, 4th + 6th and 5th + 6th irrigations, respectively, as compared with normal irrigation. The high seed yield at normal irrigation treatment may be due to the increases of number and weight of pods per plant, weight of 100-seed and seed yield per soybean plant. The results suggest that detrimental effect of skipping 3rd + 4th or 3rd + 5th irrigations on seed yield of soybean plant surpassed that of skipping other irrigations.

These results are in harmony with those reported by Bilteanu *et al.* (1974), Doss and Thurliow (1974), Doss *et al.* (1974), Ashley and Ethridge (1978), Sherif (1978), Abdel-Gawad *et al.* (1983), Korte *et al.* (1983), Badran (1986), Sorour *et al.* (1988), Abdalla *et al.* (1992) and Ashoub *et al.* (1992).

Biological yield (kg/fed.) as affected by irrigation treatments was similar to that of seed yield (kg/fed.) as shown in Table (7). Biological yield of soybean increased significantly by normal irrigation than that of other treatments. Biological yield per fed. reached its maximum weight (3854.55 kg/fed.) by normal irrigation, whereas it reached its minimum weight (3048.51 kg/fed.) by skipping 3rd + 5th irrigations treatment.

These results agree with the results obtained by Ali (1981), Abdel-Gawad *et al.* (1983) and Kassab (1993) who indicated that biological yield was decreased as soil moisture stress increased by skipping any irrigation at different developmental stages as compared with unskipped.

Generally, it is worthily to be stated that normal irrigation of soybean plant (irrigating the plants six times) produced the highest seed yield as well as biological yield per fed.. On the other hand, skipping the third or the fourth irrigations (after 55 and 70 days from planting) caused a reduction in the above traits. Skipping fifth or sixth irrigation (after 85 and 100 days from planting) did not show a marked depression in yield as well as in yield components of soybean plant.

It seems that water supply to soybean plant at vegetative as well as pod formation period is very essential to produce higher yield. Sever water stress at these periods, may reduce CO_2 exchange, photothynsis rate which account much for decreasing dry matter production and accumulation.

C- Chemical contents:

The results of the combined analysis of 1991, 1992 and 1993 seasons which are reported in Table (8) indicated clearly that photosynthetic pigments of soybean leaves i.e. chlorophyll "a", chlorophyll "b", total chlorophyll "a+b" and carotenoides were affected significantly by irrigation treatments. Chlorophyll "a" and chlorophyll "b" increased by normal irrigation treatment, but without any significance between skipping 3rd + 6th irrigations treatments for chlorophyll "a" as well as skipping 5th + 6th irrigations treatments for chlorophyll "b" as shown in Table (8). Chlorophyll "a" and chlrophyll "b" reached its maximum concentration by normal irrigation treatment, whereas it reached its minimum concentration by skipping 3rd + 4th irrigations treatment.

Regarding to the concentration of chlorophyll "a+b" as influenced by irrigation treatments, it could be shown that there were no significant differences between the normal irrigation and skipping 3rd + 6th as well as skipping 5th + 6th irrigations. Total chlorophyll reached its minimum value by skipping 3rd + 4th irrigations. The differences of total chlorophyll between treatments of skipping 3rd + 4th and 3rd + 5th irrigations were not significant.

Irrigation treatments affected significantly carotenoides concentration in soybean leaves as shown in Table (8). There were no significant differences in carotenoides concentration between

Table (8): Effect of irrigation treatments on photosynthesis pigments in soybean leaves after 90 days from planting.

Combined analysis of 1991, 1992 and 1993 seasons

Irrigation treatments	Pigments in mg/100 g fresh weight			
	Chlorophyll "a"	Chlorophyll "b"	Chlorophyll "a+b"	Carotenoides
Normal irrigation	359.15a	225.52a	584.67a	253.79ab
Skipping 3rd+4th irrigations	312.52d	165.66e	478.18d	242.51bc
Skipping 3rd+5th irrigations	315.57cd	180.91d	496.48cd	241.19c
Skipping 3rd+6th irrigations	349.87ab	200.46bc	550.33ab	250.83abc
Skipping 4th+5th irrigations	325.66cd	206.18b	531.84b	242.48bc
Skipping 4th+6th irrigations	319.45cd	192.11c	511.56c	253.12ab
Skipping 5th+6th irrigations	335.41b	220.44a	555.85a	258.26a

normal irrigation and skipping 3rd + 6th, 4th + 6th and 5th + 6th irrigations treatments, also between skipping 3rd + 4th, 3rd + 6th, 4th + 5th and 4th + 6th irrigations treatments.

These results suggest that chlorophyll "a" and "b" as well as carotenoides are all strongly affected by water supply especially at the first period of vegetative growth. It could be noted that leaf area increased to its maximum value by skipping 5th + 6th irrigations. On the other hand, it reached its minimum value by skipping 3rd + 5th irrigations as shown in Table (6).

These results are in harmony with those obtained by Abo El-Seud (1987) on soybean. He found that decreasing the available soil moisture content resulted in a continuoues decline in chlorophyll "a" + chlorophyll "b". Kandil *et al.* (1988) observed that chlorophyll "a" and "b" displayed remarkable variations with changes in moisture stress. Increasing in moisture stress resulted in a decrease in chlorophyll "a" and chlorophyll "b". Abo El-Kheir (1990) concluded that there is a constant trend towards the decrease in chlorophyll "a" and "b" with increase in water stress.

Table (9) shows the effect of irrigation treatments on chemical contents of soybean seeds.

Irrigation treatments did not affect significantly oil percentage, protein percentage, carbohydrates percentage, nitrogen percentage, phosphorus percentage and potassium percentage as shown in Table (9).

Table (9): Effect of irrigation treatments on Chemical contents of soybean seeds.

Combined analysis of 1991, 1992 and 1993 seasons

Irrigation treatments	Oil %	Oil yield (kg/fed.)	Protein %	Protein yield (kg/fed.)	Carbohy-rates %	N %	P %	K %
Normal irrigation	21.24a	214.61a	35.48a	357.35a	16.50a	5.68a	0.581a	1.788a
Skipping 3rd+4th irrigatons	21.68a	183.51cd	35.91a	299.63b	15.82a	5.73a	0.612a	1.841a
Skipping 3rd+5th irrigatons	20.34a	176.33d	36.02a	304.26b	16.09a	5.76a	0.592a	1.828a
Skipping 3rd+6th irrigatons	21.25a	195.27bc	35.78a	319.83ab	16.22a	5.72a	0.592a	1.804a
Skipping 4th+5th irrigations	21.72a	196.42abc	37.05a	333.61ab	16.28a	5.89a	0.599a	1.800a
Skipping 4th+6th irrigations	21.32a	199.24abc	36.99a	337.51ab	16.11a	5.92a	0.595a	1.804a
Skipping 5th+6th irrigations	21.26a	205.40ab	36.84a	356.54a	15.84a	5.75a	0.588a	1.778a

Similar results were obtained by Dimitrov (1968), Bilteanu *et al.* (1974), Plewkov (1975), Ali (1981), Abd El-Hady (1988), Abo El-Kheir (1990) and Kassab (1993). Ali (1981) observed that irrigation and missing any irrigation had no significant effect on concentrations of oil, protein, nitrogen, phosphorus and potassium in soybean seeds in the two seasons. Also Kassab (1993) found that the effect of water stress did not affect significantly potassium concentration in soybean seeds in 1991 season.

With regard to oil yield (kg/fed.), data in Table (9) showed that oil yield per fed. decreased significantly by skipping 3rd + 5th irrigations treatment than other treatments. The differences in oil yield between skipping 3rd + 4th and 3rd + 5th irrigations did not reach the 5% level of significance. Oil yield came to its maximum value by normal irrigation without any significance differences with skipping 4th + 5th, 4th + 6th and 5th + 6th irrigations treatments. Oil yield increased significantly at normal irrigation treatment by 31.1 and 38.28 kg/fed. than that of skipping 3rd + 4th and 3rd + 5th irrigations treatments, respectively. Oil yield reached its minimum value by skipping 3rd + 5th irrigations treatment.

These results may be due to the increase in soybean yield by normal irrigation as shown in Table (7).

These results are in harmony with those reported by Lutz and Jones (1975), Ali (1981), Sorour *et al.* (1988) and Kassab (1993).

Lutz and Jones (1975) found that the oil yield of soybean (kg/ha.) was increased with irrigation. Irrigation increased the oil yield by 86 kg/ha. or 19%. Ali (1981) observed that the oil yield (kg/fed.) was significantly affected by increasing irrigation intervals in 1980 and 1981 seasons. Sorour *et al.* (1988) stated that the high irrigation level applied during the entire season or after early flowering and early pod filling increased the oil yield of soybean. Kassab (1993) indicated that the oil yield of soybean (kg/fed.) was significantly decreased under stress conditions by skipping one irrigation at any tested stage in 1990 season.

The effect of irrigation treatments on protein yield (kg/fed.) of soybean was similar to that obtained on oil yield. Protein yield increased to reach its maximum peak at normal irrigation treatment without significant differences with skipping 3rd +6th, 4th + 5th, 4th + 6th and 5th + 6th irrigations treatments. On the other hand, protein yield decreased significantly by 57.72 and 53.09 kg/fed. by skipping 3rd + 4th and 3rd + 5th irrigations as compared with normal irrigation, respectively.

These results may be due to the increases of seed yield of soybean by normal irrigation as shown in Table (7).

These results are in good agreement with those reported by Ali (1981), Puech and Bouniols (1986), Sorour *et al.* (1988) and Kassab (1993). They concluded that the yield of protein was significantly decreased under water stress by skipping one irrigation at any tested stage or elongation of irrigation intervals.

II- Effect of nitrogen fertilizer:

A- Growth characters:

Effect of nitrogen fertilizer rates on growth characters of soybean plants in combined analysis of 1991, 1992 and 1993 seasons are shown in Table (10).

Nitrogen rates affected significantly number of leaves per plant, number of pods per plant, leaf area and leaf area index. On the other hand, there were no significant differences in plant height and number of branches per plant as a result of nitrogen fertilizer rates.

1. Plant height and number of branches per plant:

The difference in plant height between maximum and minimum height was 1.19 cm, whereas the difference was 0.22 in number of branches without any significance difference.

In this respect, Abdel-Hafeez (1970) found that nitrogen application at different rates to soybean had no significant effect on plant height and number of branches per soybean plant. Ali (1981) showed that number of branches per plant of soybean in 1981 season was not affected by N fertilizer. Abdalla (1983) stated that the number of branches per soybean plant was not affected by N-fertilizer. On the other hand, Ashour *et al.* (1969), Ham *et al.* (1975), Saad *et al.* (1983), Sharaf (1984) and Ashoub *et al.* (1993) come to oposite results. They found that nitrogen fertilizer increased plant height and number of branches per soybean plant.

Table (10): Effect of nitrogen fertilizer rates on growth characters of soybean plants after 90 days from planting.

Combined analysis of 1991, 1992 and 1993 seasons

Nitrogen rates (kg/fed.)	Plant height cm	No. of branches/ plant	No. of leaves/ plant	No. of pods/ plant	Leaf area/ plant cm^2	Leaf area index cm^2/cm^2	Fresh weight (g)				Dry weight (g)			
							Leaves	Stems	Pods	Total	Leaves	Stems	Pods	Total
Zero	76.62a	3.25a	17.14c	33.32b	1580.11b	5.26b	29.25b	26.62b	39.51b	95.38d	10.49b	9.77c	13.21c	33.47d
15	77.81a	3.40a	19.23ab	36.35a	1910.88a	6.36a	33.73a	30.49a	43.19a	107.41c	11.57a	11.23a	13.97b	36.77c
30	77.37a	3.47a	19.80a	37.72a	1835.54a	6.11a	34.78a	32.37a	45.69a	112.84a	12.00a	11.90a	15.14a	39.04a
45	77.66a	3.33a	18.38abc	37.17a	1837.85a	6.12a	35.77a	31.46a	45.87a	113.10a	11.93a	11.21ab	14.64ab	37.78b
60	77.45a	3.26a	17.90bc	35.01ab	1613.66b	5.37b	33.65a	30.96a	45.68a	110.29b	11.68a	10.78b	14.05bc	36.51c

2. Number of leaves per plant:

Nitrogen fertilizer affected significantly number of leaves per soybean plant as shown in Table (10). Number of leaves per plant increased significantly by 2.66 as a result of increasing nitrogen level from zero to 30 kg N/fed.. There were no significant differences in number of leaves per plant between 15, 30 and 45 kg N/fed. as well as 15, 45 and 60 kg N/fed., or zero, 45 and 60 kg N/fed. Maximum and minimum number of leaves per plant were 19.80 and 17.14 as a result of nitrogen rates of 30 and zero kg N/fed. , respectively.

This result is in harmony with those reported by Sharaf (1980), Ali (1981), Yakout *et al.* (1981), Aamer (1982) and Kassab (1993). Saharaf (1980) found that N application at the rate of 45 kg N/fed. significantly increased number of leaves per soybean plant at 60 days after sowing. Yakout *et al.* (1981) concluded that nitrogen fertilizers increased number of leaves per plant. Kassab (1993) indicated that number of leaves per soybean plant increased by nitrogen fertilizer up to 20 kg N/fed. which resulted the highest number of leaves per plant.

3. Number of pods per plant:

Nitrogen rates affected significantly number of pods per soybean plant as shown in Table (10). The differences in number of pods per plant as affected by nitrogen fertilizer were not significant between zero and 60 kg N/fed. as well as between 15, 30, 45 and 60 kg N/fed. as shown in Table (10). Number of pods

reached the maximum by adding 30 kg N/fed., whereas the control treatment gave the minimum number.

Supporting results were obtained by Ali (1981), Osman (1985) and Barsoum and Abdel-Gawad (1990).
Ali (1981) found that number of pods per soybean plant increased with N fertilizer equal to 60 kg N/fed. as compared with the unfertilized treatment. Osman (1985) mentioned that increasing nitrogen rates up to 80 kg N/fed. increased number of pods per soybean plant as compared with the control treatment (zero-N). Barsoum and Abdel-Gawad (1990) reported that number of pods per plant of soybean was significantly increased with increasing N-levels up to 60 kg N/fed. as compared with zero-N treatment.

4. Leaf area and leaf area index:

Nitrogen fertilizer affected significantly leaf area and leaf area index per soybean plant as presented in Table (10). Leaf area as well as leaf area index as affected by nitrogen rates existed the same trend of number of leaves per plant. Leaf area and leaf area index per plant increased significantly by 330.77 cm^2 and 1.1 cm^2/cm^2 by increasing nitrogen level from zero to 15 kg N/fed., respectively. There were no significance differenences in leaf area and leaf area index between 15, 30 and 45 kg N/fed., also between zero and 60 kg N/fed..

Similar results were obtained by Serova and Posyanov (1979), Eisa (1980), Yakout *et al.* (1981), Aamer (1982), El-Kady

et al. (1982), Abdalla (1983), Mohamed (1985), Hassanein (1987), Ashoub *et al.* (1992) and Kassab (1993).

5. Fresh weight:

Nitrogen fertilizer affected significantly fresh weight of leaves, stems and pods of soybean plant as shown in Table (10). Fresh weight of leaves, stems and pods increased significantly by adding nitrogen fertilizer up to 15 kg N/fed.. Further increase in nitrogen rate did not affect these characters. There were no significance differences in fresh weight of leaves, stems and pods per plant between 15, 30, 45 and 60 kg N fed.. The difference of fresh weights of leaves, stems and pods per plant between zero and 15 kg N/fed. were 4.48, 3.87 and 3.68 g/plant, respectively.

Data on total fresh weight as affected by nitrogen rates was similar to that obtained on fresh weight of leaves, stems and pods per plant. Total fresh weight/plant increased significantly by applying nitrogen up to 15 and 30 kg N/fed.. Further increase in nitrogen rates did not affect total fresh weight of soybean plant. The increase percentage in total fresh weight of plant were 12.61, 18.30, 18.57 and 15.63% by applying the rates of 15, 30, 45 and 60 kg N/fed., respectively as compared with the control (zero-N).

These results are quite expected since nitrogen fertilizer increased the vegetative growth of soybean plants and increased photosynthetic activity.

These results are in agreement with those reported by Bassiem (1978), Ali (1981), Barsoum and Abdel-Gawad (1990) and Kassab (1993).

6. Dry weight:

Data in Table (10) elucidate that dry weight of leaves, stems and pods per soybean plant were affected significantly by nitrogen fertilizer. Leaves and stems dry weight increased as nitrogen fertilizer increased up to 15 kg N/fed., whereas dry weight of pods increased up to 30 kg N/fed.. The maximum dry weight of leaves, stems and pods were 12.00, 11.90 and 15.14 g/plant by applying the rate of 30 kg N/fed., respectively, whereas minimum dry weight were 10.49, 9.77 and 13.21 g/plant for the same respective characters by the control treatment.

Total dry weight of soybean plant increased significantly as nitrogen fertilizer increased up to 30 kg N/fed.. Total dry weight increased significantly by 5.57 g by applying 30 kg N/fed. as compared with control. Increasing total dry weight as a result of increasing nitrogen rates may be due to the increases in dry weight of leaves, stems and pods per plant as shown in Table (10).

These results are in harmony with those obtained by Bassiem (1978), Behran *et al.* (1979), Eisa (1980), Sharaf (1980), Ali (1981), Yakout *et al.* (1981), Abdalla (1983), Saad *et al.* (1983) and Bona *et al.* (1991).

Generally, it could be concluded that numbers of leaves and pods, leaf area and leaf area index as well as fresh and dry weights of leaves, stems and pods of soybean plant increased as nitrogen fertilizer increased up to 15 kg N/fed.. Further increase in nitrogen rate did not increase significantly growth characters in our study. In addition, it could be showed that increasing nitrogen fertilizer up to 60 kg N/fed. caused a decrease in number of leaves, number of pods, leaf area, leaf area index and total dry weight of soybean plant as compared by 15 kg N/fed.. These results may be due to that soybean is a leguminous crop. *Rhizobium japonicum* as a symbiosis bacteria of soybean which fixing nitrogen to supply the plant by its needs from nitrogen especially after one or two weeks from planting. At the first period of growth, soybean plant needs about 10 to 15 kg N/fed. till time of starting nitrogen fixation to supply soybean plant with its needs of nitrogen. Increasing nitrogen up to 60 kg N/fed. may inhibit fixation of nitrogen by Rhizobium bacteria.

B- Yield and yield components:

Effect of nitrogen fertilizer levels on yield and yield components of soybean plants in combined analysis of 1991, 1992 and 1993 seasons are shown in Table (11).

It is quite clear from Table (11) that nitrogen fertilizer rates affected significantly number and weight of pods per soybean plant, yield of plant, seed yield and biological yield (kg/fed.). On the other hand, nitrogen rates did not affect number of seeds per pod and weight of 100-seed.

Table (11): Effect of nitrogen fertilizer rates on yield and yield components of soybean plant at harvest time.

Combined analysis of 1991, 1992 and 1993 seasons

Nitrogen rates (kg/fed.)	No. of pods/ plant	Weight of pods/plant (g)	No. of seeds/pod	Weight of 100-seed (g)	Yield of plant (g)	Seed yield (kg/fed.)	Biological yield (kg/fed.)
Zero	49.07c	31.17b	2.78a	16.57a	17.08b	859.16c	3159.30c
15	54.63b	33.83a	2.83a	16.45a	19.29a	919.71b	3519.75ab
30	57.22a	35.54a	2.89a	16.61a	19.06a	929.52b	3372.14b
45	53.90b	33.88a	2.90a	16.67a	19.34a	986.61a	3573.61a
60	50.17c	30.93b	2.85a	16.36a	16.99b	934.52b	3475.95ab

1. Number of pods per plant:

Nitrogen fertilizer had a significant effect on number of pods per soybean plant. Number of pods per plant increased to its maximum number was by adding 30 kg N/fed., whereas the minimum number obtained at zero level of nitrogen. Here it should be noticed that increasing nitrogen up to 60 kg N/fed. did not increase significantly number of pods per plant as compared with zero level of nitrogen. There was no significant difference in number of pods per plant between 15 and 45 kg N/fed. as well as between zero and 60 kg N/fed..

These results coincide with the findings of Abdel-Gawad *et al.* (1983) who found that number of pods per soybean plant increased significantly by increasing the rate of nitrogen fertilizer up to 60 kg N/fed. in the two seasons.

2. Weight of pods per plant:

Weight of pods per soybean plant increased significantly by adding nitrogen fertilizer up to 15 kg N/fed.. There was no significant difference in weight of pods between 15, 30 and 45 kg N/fed., also between zero and 60 kg N/fed.. Increasing pods weight as a result of increasing nitrogen rate may be due to the increase in number of pods per plant.

These results are in harmony with those obtained by Yakout *et al.* (1981) who fertilized soybean cv. "Clark" with 40 or 60 kg N/fed.. They showed that increasing N rate increased weight of pods per plant. Abdel-Gawad *et al.* (1983) indicated that the

weight of pods per soybean plant was increased significantly by increasing the rates of nitrogen fertilizer up to 60 kg N/fed. in both seasons.

3. Number of seeds per pod:

Number of seeds per pod was not affected by nitrogen levels as shown in Table (11).

Similar results were obtained by Fayed *et al.* (1986) and Kassab (1993) who found that number of seeds per pod of soybean plant was not significantly affected with nitrogen fertilizer rate up to 30 kg N/fed..

4. Weight of 100-seed:

Nitrogen level had no significant effect on weight of 100-seed as shown in Table (11).

These results are similar to those reported by Abdel-Hafeez (1970) and Ashoub, *et al.*(1992) who reported that nitrogen application had no significant effect on 100-seed weight of soybean.

5. Weight of seeds per plant:

Effect of nitrogen rates on yield of plant was similar to that obtained on weight of pods per soybean plant. Yield of plant reached its maximum weight by rate of 45 kg N/fed., whereas it reached its minimum weight by 60 kg N/fed.. The differences in

seed yield per plant between 15, 30 and 45 kg N/fed. were not significant as well as between zero and 60 kg N/fed.

This result is expected since nitrogen fertilizer increased weight of pods per plant (Table, 11).

Similar results were also reported by Eisa (1980), Abdel-Gawad *et al.* (1983), Haggag *et al.* (1984) and Hammam (1986). They concluded that weight of seeds per soybean plant increased significantly by increasing nitrogen rates up to 45 kg N/fed..

6. Yield:

Concerning seed yield (kg/fed.) of soybean, data presented in Table (11) demonstrate that nitrogen levels affected significantly seed yield (kg/fed.). Seed yield per fed. increased as nitrogen fertilizer increased by 6.98, 8.19, 14.83 and 7.77% by adding 15, 30, 45 and 60 kg N/fed., respectively as compared with zero level. The differences in seed yield per fed. between 15, 30 and 60 kg N/fed. were not significant. The maximum and minimum seed yield per fed. were 986.61 and 859.16 kg at the rates of 45 and zero kg N/fed., respectively.

Increasing seed yield per fed. as a result of increasing nitrogen levels may be due to the increase of seed yield per plant (Table, 11).

These results are in harmony with those obtained by Pettiet (1971), Aleman *et al.* (1976), Raicheva (1977), Chamber (1979),

Abdel-Gawad *et al.* (1983), Haggag *et al.* (1984), Hammam (1986) and Barsoum and Abdel-Gawad (1990).

Pettiet (1971) found that application of 22.4, 89.6 and 179.2 kg N/ha. increased soybean seed yield by 168, 195 and 262 kg/ha., respectively, as compared with zero-level. Abdel-Gawad *et al.* (1983), Haggag *et al.* (1984) and Barsoum and Abdel-Gawad (1990) reported that seed yield of soybean per fed. increased gradually by increasing nitrogen fertilizer up to 60 kg N/fed..

Table (11) shows that nitrogen fertilizer increased significantly biological yield (kg/fed.) of soybean. Biological yield per fed. increased by increasing nitrogen level up to 15 kg N/fed.. Biological yield increased by 360.45 kg/fed. at 15 kg N/fed. as compared by zero level. The differences in biological yield between 15, 45 and 60 kg N/fed. were not significant, also between 15, 30 and 60 kg N/fed.. The increase in biological yield by applying nitrogen fertilizer may be due to the increase in seed yield (Table, 11).

These results were in agreement with those reported by Sharaf (1980) who found that application of N levels up to 45 kg N/fed. affected significantly biological yield per fed. of soybean in both seasons. Kassab (1983) pointed that the application of 20 kg N/fed. in the first season gave a slight increase in the biological yield of soybean when compared with unfertilized treatment, but the increment failed to reach the 5% level of significance.

C- Chemical contents:

Data in Table (12) show the effect of nitrogen fertilizer on photosynthetic pigments i.e. chlorophyll "a", "b", total chlorophyll "a+b" and carotenoides in soybean leaves after 90 days from planting as a combined analysis of 1991, 1992 and 1993 seasoms.

Nitrogen fertilizer rates affected significantly photosynthetic pigments. Chlorophyll "a", "b", total chlorophyll and carotenoides increased significantly as nitrogen rates increased up to 15 kg . N/fed..

It could be shown that chlorophyll "a" and carotenoides increased by 38.96 and 32.96 mg/100gm as nitrogen fertilizer increased to 15 kg N/fed. as compared with zero level respectively. There were no significant differences in chlorophyll "a" and carotenoides between 15, 30, 45 and 60 kg N/fed.

With regard to chlorophyll "b" and total chorophyll, it could be shown in Table (12) that it increased as nitrogen increased to 15 kg N/fed.. The differences in chlorophyll "b" and total chlorophyll between 15 and 60 kg N/fed. as well as between 30 and 45 kg N/fed. were not significant. Chlorophyll "b" and carotenoides reached there maximum value at 15 and 60 kg N/fed. respectively, whereas the minimum values resulted at zero level of nitrogen.

Table (12): Effect of nitrogen fertilizer rates on photosynthesis pigments in soybean leaves after 90 days from planting.

Combined analysis of 1991, 1992 and 1993 seasons

Nitrogen rates (kg/fed.)	Pigments in mg/100 g fresh weight			
	Chlorophyll "a"	Chlorophyll "b"	Chlorophyll "a+b"	Carotenoides
Zero	295.84b	174.70c	470.54c	224.55b
15	334.80a	213.61a	548.41a	257.51a
30	337.15a	192.70b	529.85b	254.77a
45	341.62a	199.59b	541.21ab	257.41a
60	346.03a	213.16a	559.19a	250.23a

These results may be attributed to the great increase in number and size of cells of green leaves with nitrogen application. Nitrogen is necessary for building more chlorophyll units which in turn encourages plant to convert light energy to metabolites.

These results were in agreement with those obtained by Ali (1981), Yakout *et al.* (1981), Osman (1985) and Hassanein (1987).

Nitrogen fertilizer did not affect significantly oil percentage, carbohydrate percentage, phosphorus percentage and potassium percentage, whereas it affected significantly protein percentage, oil yield, protein yield and nitrogen percentage as a combined analysis of 1991, 1992 and 1993 seasons as shwon in Table (13).

Oil percentage in soybean seeds did not affect by nitrogen fertilizer rates as shown in Table (13). There was a slight decrease in oil content as nitrogen fertilizer increased.

These results are in harmony with those reported by Nur (1977) and Ali (1981) who found that nitrogen utilization decreased oil content in soybean seeds, but this effect did not reach the significance level.

Oil yield (kg/fed.) of soybean was affected significantly by increasing nitrogen fertilizer levels as shown in Table (13). Oil yield increased by 24.19 kg/fed. as a result of increasing nitrogen level from zero to 45 kg N/fed.. There were no significant

Table (13): Effect of nitrogen fertilizer rates on Chemical contents of soybean seeds.

Combined analysis of 1991, 1992 and 1993 seasons

Nitrogen rates (kg/fed.)	Oil %	Oil yield (kg/fed.)	Protein %	Protein yield (kg/fed.)	Carbohy-rates %	N %	P %	K %
Zero	21.50a	183.81c	32.33c	274.46c	16.65a	5.13c	0.596a	1.805a
15	21.41a	197.06ab	36.86ab	336.46b	16.09a	5.90ab	0.602a	1.825a
30	20.79a	189.77bc	38.61a	345.39ab	16.14a	6.13a	0.586a	1.794a
45	21.29a	208.00a	39.46a	374.48a	15.60a	6.29a	0.586a	1.796a
60	21.31a	200.49ab	34.22bc	318.31b	15.71a	5.45bc	0.599a	1.811a

differences in oil yield between 15, 45 and 60 kg N/fed.. Oil yield per fed. reached its maximum peak (208.00 kg/fed.) at 45 kg N/fed., whereas, it reached its minimum peak (183.81 kg/fed.) at zero level.

This result is expected since seed yield increased significantly at a rate of 45 kg N/fed. as shown in Table (11).

Similar results were obtained by Ham *et al.* (1975), Ali (1981) Abdalla (1983) and Kassab (1993). Abdalla (1983) who pointed that oil yield (kg/fed.) of soybean significantly increased by increasing N fertilizer up to 90 kg N/fed.. Kassab (1993) found that in 1990 season increasing nitrogen fertilizer up to 20 kg N/fed. increased oil yield (kg/fed) comparing with other treatments.

Nitrogen fertilizer levels affected significantly protein percentage in soybean seeds as shown in Table (13). There was a consistent increase in protein percentage by adding nitrogen rate up to 45 kg N/fed.. Further increase in nitrogen rate up to 60 kg N/fed. caused a slight decrease in protein percentage. Protein percentage increased by 4.53, 6.28 and 7.13% by adding 15, 30 and 45 kg N/fed., respectively as compared with zero level. Increasing protein percentage as a result of increasing N rates may be due to the increase in the plant tissues. Ashour *et al.* (1969), Ham *et al.* (1975), Abdalla (1983), Abdel-Ghany (1988), Salwau (1989) and Ashoub, *et al.* (1992) come to similar conclusion. Abdalla (1983) found that protein percentage in soybean seeds

increased by increasing nitrogen fertilizer up to 90 kg N/fed.. Ashoub *et al.* (1992) indicated that when soybean plants were fertilized by 20 kg N/fed., seeds contained the highest percentage of protein compared to other treatments.

Protein yield (kg/fed.) of soybean was affected by nitrogen levels as shown in Table (13). Protein yield per fed. reached its maximum peak (374.48 kg/fed.) at 45 kg N/fed. without any significant difference with 30 kg N/fed.. Increasing nitrogen fertilizer levels to 45 kg N/fed. increased significantly protein yield per fed. by 100.02 kg than that of zero level. The differences in protein yield per fed. between 15, 30 and 60 kg N/fed. as well as between 30 and 45 kg N/fed. were not significant.

This result is expected because seed yield increased significantly at rate of 45 kg N/fed. (Table, 11) as well as protein percentage which increased at 45 kg N/fed..

Similar results were reported by Ham *et al.* (1975), Abdalla (1983), Ashour and Thalooth (1983) and Kassab (1993).
Abdalla (1983) found that protein yield (kg/fed.) of soybean increased by increasing N fertilizer up to 90 kg N/fed.. Kassab (1993) showed that in 1990 season, increasing nitrogen fertilizer up to 20 kg N/fed. increased protein yield (kg/fed.) of soybean comparing with other treatments.

Nitrogen fertilizer levels did not affect carbohydrate percentage in soybean seeds as shown in Table (13). There was a

slight decrease in carbohydrate content as nitrogen fertilizer increased.

These results are in harmony with those obtained by Ashoub *et al.* (1993) who found that when soybean plants fertilized by 20 kg N/fed., seeds contained the highest percentage of carbohydrate compared to other treatments, whereas the lowest carbohydrate value was obtained by fertilizing soybean plants by 30 kg N/fed..

Nitrogen percentage in soybean seeds was affected by increasing nitrogen levels as shown in Table (13). Nitrogen Percentage increased by increasing nitrogen level up to 15 kg N/fed.. Further increase in nitrogen rate up to 45 kg N/fed. did not affect nitrogen percentage. There was no significant difference in nitrogen percentage between zero and 60 kg N/fed.. Nitrogen percentage reached its maximum peak at 45 kg N/fed., whereas it reached its minimum peak at zero level.

These results are in agreement with those obtained by Hamdi *et al.* (1981), Yakout *et al.* (1981), Bassiem (1983), Watanabe *et al.* (1983), Osman (1985), Hassanein (1987) and Kassab (1993).

Phosphorus percentage as well as potassium percentage in soybean seeds was not affected by nitrogen levels as shown in Table (13). Phosphorus and potassium percentages increased by increasing nitrogen level up to 15 kg N/fed., but the difference was not significant.

These results are in harmony with those reported by Samepet (1978), Ali (1981), Bassiem (1983) and Kassab (1993) who reported that phosphorus and potassium percentages in soybean seeds were not significantly affected by appling different nitrogen levels.

Generally, it could observed from Table (13) that nitrogen fertilizer affected protein percentage, nitrogen percentage as well as oil yield and protein yield (kg/fed.). These traits increased significantly as nitrogen fertilizer increased up to 15 kg N/fed.. Increasing N rates up to 60 kg N/fed. did not affect these traits. This is to be expected since soybean is a leguminous crop which needs a small amount of nitrogen at the first period of growth. Increasing N up to 60 kg N/fed. may inhibit symbiosis bacteria.

III- Effect of the interaction between irrigation and nitrogen fertilizer treatments:

A) Growth characters of soybean plant:

The effect of interaction between irrigation treatments and nitrogen fertilizer rates on numbers of branches, leaves, pods per plant, leaf area per plant, leaf area index, fresh and dry weight of leaves, stems and total fresh and dry weights per plant were not statisitically significant, showing that each of the two factors acted independently. Consequently the data were excluded.

On the other hand, the effect of interaction on plant height, fresh and dry weight of pods after 90 days from planting was significant.

Plant height:

Plant height was significantly affected by the interaction between irrigation treatments and nitrogen fertilizer rates as a combined analysis of 1991, 1992 and 1993 seasons as shown in Table (14). Plant height was not affected by increasing nitrogen fertilizer from zero to 60 kg N/fed. at normal irrigation as well as skipping the third and fifth irrigations. Increasing nitrogen fertilizer from zero to 60 kg N/fed. increased plant height by 8.33 and 7.00 cm when the third + sixth and fourth + fifth irrigations were skipped, respectively. With regard to skipping irrigations it is clear from Table (14) that skipping 3rd+4th, 3rd+5th and 3rd+6th irrigations decreased plant height as compared by skipping any other two irrigations under all nitrogen fertilizer rates. It seems that skipping the third and fourth or fifth or sixth irrigations is more effective on plant height under all nitrogen fertilizer rates. Plant height increased to its maximum value (87.25 cm) at skipping 4th + 6th irrigations and fertilized by 15 kg N/fed., whereas it reached its minimum value (64.72 cm) by skipping 3rd+4th irrigations and fertilized by 15 kg N/fed.. These results suggest that skipping the third irrigation is more effective on plant height.

Fresh weight of pods per plant:

The interaction between irrigation treatments and nitrogen fertilizer rates affected significantly fresh weight of pods of soybean plant as a combined analysis of 1991, 1992 and 1993 seasons (Table, 15). Fresh weight of pods per plant increased

Table (14): Effect of interaction between irrigation treatments and nitrogen fertilizer rates on plant height (cm) after 90 days from planting.

Combined analysis of 1991, 1992 and 1993 seasons

Irrigation treat. / N rates (kg/fed.)	Normal irrigation	Skipping 3rd+4th irrigations	Skipping 3rd+5th irrigations	Skipping 3rd+6th irrigations	Skipping 4th+5th irrigations	Skipping 4th+6th irrigations	Skipping 5th+6th irrigations
Zero	81.86ABa	73.66C a	73.44C a	66.05D bc	75.66BCb	82.16ABab	83.52A a
15	83.80A a	64.72C b	69.41BCa	73.86B a	82.05A ab	87.25A a	84.41A a
30	84.13A a	72.25B a	70.91BCa	64.74C c	84.80A a	79.86A b	84.88A a
45	85.75A a	74.00BCa	71.38C a	71.69C ab	82.14A ab	78.77A b	79.88ABab
60	81.25ABa	70.44C b	75.25BCa	74.38BCa	82.66A a	80.94ABab	76.44ABCb

Table (15): Effect of interaction between irrigation treatments and nitrogen fertilizer rates on fresh weight of pods per plant (g) after 90 days from planting.

Combined analysis of 1991, 1992 and 1993 seasons

Irrigation treat. / N rates (kg/fed.)	Normal irrigation	Skipping 3rd+4th irrigations	Skipping 3rd+5th irrigations	Skipping 3rd+6th irrigations	Skipping 4th+5th irrigations	Skipping 4th+6th irrigations	Skipping 5th+6th irrigations
Zero	43.68ABb	34.75C b	37.45BCc	34.62C b	37.74BCb	46.85A a	41.51ABCb
15	46.03ABb	35.74C b	39.28BCc	41.38BCa	43.52ABab	46.47ABa	50.27A a
30	54.07A a	34.09D b	41.07C bc	46.45BCa	44.28BCab	48.47ABa	51.38ABa
45	47.69A ab	45.02ABa	50.38A a	41.01B ab	46.59ABa	47.42ABa	43.01ABb
60	44.53ABb	42.79B a	46.72ABab	40.45B ab	47.79ABa	50.62A a	46.86ABab

significantly by skipping 4th+6th, 5th+6th, normal irrigation, skipping 3rd+5th and 4th+6th irrigations and nitrogen fertilizer levels of zero, 15, 30, 45 and 60 kg N/fed., respectively. With regard to nitrogen fertilizer levels, it could be shown that fresh weight of pods increased by appling nitrogen rates of 30, 45, 45, 30, 60 and 30 kg N/fed. under normal irrigation, skipping 3rd+4th, 3rd+5th, 3rd+6th, 4th + 5th and 5th+6th irrigations respectively. Fresh weight of pods reached its maximum value (54.7 g) by normal irrigation and 30 kg N/fed., whereas it reached its minimum value (34.09 g) by skipping 3rd+4th irrigations and 30 kg N/fed.. The differences of fresh weight of pods between the above two treatments is 19.98 g.

Dry weight of pods per plant:

The effect of interaction between irrigation treatments and nitrogen fertilizer levels affected significantly dry weight of pods per soybean plant as a combined analysis of 1991, 1992 and 1993 seasons as shown in Table (16). With regard to nitrogen fertilizer, dry weight of pods after 90 days from planting increased significantly by adding 30 kg N/fed. with normal irrigation, skipping 3rd+4th or 3rd+6th, whereas it increased by skipping 5th+6th irrigations with applying 45 kg N/fed.. Nitrogen fertilizer did not affect dry weight of pods by skipping 3rd+5th, 4th+5th or 4th+6th irrigations. It could be observed from Table (16) also that dry weight of pods came to its minimum value by skipping 3rd+4th irrigations and zero, 45 and 60 kg N/fed., whereas the minimum dry weight of pods at 30 kg N/fed. was by skipping

Table (16): Effect of interaction between irrigation treatments and nitrogen fertilizer rates on dry weight of pods per plant (g) after 90 days from planting.

Combined analysis of 1991, 1992 and 1993 seasons

Irrigation treat. / N rates (kg/fed.)	Normal irrigation	Skipping 3rd+4th irrigations	Skipping 3rd+5th irrigations	Skipping 3rd+6th irrigations	Skipping 4th+5th irrigations	Skipping 4th+6th irrigations	Skipping 5th+6th irrigations
Zero	14.46A b	10.11C b	12.74ABa	11.67BCb	13.86ABa	15.05A a	14.55A b
15	14.79A b	12.94A b	13.09A a	13.34A ab	13.54A a	14.89A a	15.18A ab
30	17.49A a	15.67ABa	13.01C a	15.36ABCa	13.47BCa	15.97ABa	15.02ABCab
45	14.49BCb	12.74C b	13.85BCa	13.03C ab	14.26BCa	16.47ABa	17.61A a
60	14.40A b	10.96B b	14.63A a	13.30ABab	15.58A a	14.91A a	14.57A b

3rd+5th irrigations. Skipping irrigation did not affect significantly dry weight of pods when nitrogen rate was 15 kg N/feddan. Dry weight of pods came to its maximum value by skipping 5th+6th irrigations and 45 kg N/fed. over all interaction data.

B- Yield and Yield components:

The effect of the interaction between irrigation treatments and nitrogen fertilizer on weight of pods per plant, number of seeds per pod, weight of 100-seed and biological yield per fed. were not statistically significant, showing that the factors of the interaction act independently, consequently the data were excluded.

Number of pods per plant:

Number of pods per plant was affected significantly by the interaction between irrigation treatments and nitrogen fertilizer as a combined analysis of 1991, 1992 and 1993 seasons as shown in Table (17). With regard to skipping irrigations under the levels of nitrogen rates, it could be noted from Table (17) that number of pods decreased to its minimum values by skipping 3rd+6th, 3rd+5th, 3rd+5th, 3rd+5th and 3rd+6th irrigations at zero, 15, 30, 45 and 60 kg N/fed., respectively. These results suggest that the more effective two irrigations on number of pods per plant are the third and the fifth irrigations under nitrogen fertilizer levels. Also, it is clear from data presented in Table (17) that number of pods increased by adding 30 kg N/fed. under skipping any two irrigations. Number of pods reached its maximum value (63.85) at

Table (17): Effect of interaction between irrigation treatments and nitrogen fertilizer rates on number of pods per plant at harvest time.

Combined analysis of 1991, 1992 and 1993 seasons

Irrigation treat. / N rates (kg/fed.)	Normal irrigation	Skipping 3rd+4th irrigations	Skipping 3rd+5th irrigations	Skipping 3rd+6th irrigations	Skipping 4th+5th irrigations	Skipping 4th+6th irrigations	Skipping 5th+6th irrigations
Zero	52.09A c	51.54ABa	48.14ABab	46.58B cd	46.67B b	47.13ABb	51.33ABc
15	53.65ABc	54.32ABa	51.28B a	54.92ABab	54.18ABa	55.62ABa	58.46A ab
30	63.05A a	55.60B a	50.35C ab	57.59B a	53.77BCa	57.45B a	62.77A a
45	59.58A ab	52.22C a	49.74C ab	50.38C bc	54.47ABCa	53.46BCa	57.41ABb
60	54.09A bc	46.68BCb	45.79C b	44.83C d	51.20ABab	52.49A a	56.08A b

normal irrigation and 30 kg N/fed., whereas it reached its minimum value (44.83) by skipping 3rd+6th irrigations and 60 kg N/fed. overall interactions data. These results suggest that the third irrigation as well as 30 kg N/fed. is more effective on number of pods per soybean plant.

Yield of plant:

The effect of interaction between irrigation treatments and nitrogen fertilizer affected significantly yield of soybean plant (g) as a combined analysis of 1991, 1992 and 1993 seasons as shown in Table (18). With regard to nitrogen fertilizer, yield of plant increased significantly by adding 45 kg N/fed. and normal irrigation, skipping 3rd+4th and 3rd+5th irrigations, whereas it increased by skipping 4th+5th and 5th+6th irrigations at 30 kg N/fed., as well as it increased by skipping 3rd+6th irrigations at 15 kg N/fed.. Nitrogen fertilizer did not affect yield of plant by skipping 4th + 6th irrigations. It could be observe from Table (18) that yield of plant came to its minimum value by skipping 3rd+5th irrigations and 30, 45 and 60 kg N/fed., whereas the minimum yield of plant was obtained by skipping 3rd + 4th irrigations at 15 kg N/fed. Overall interaction data, yield of plant came to its maximum value (21.90 g) by normal irrigation and 45 kg N/fed., whereas it came to its minimum value (14.86 g) by skipping 4th+5th irrigations and zero-N.

Table (18): Effect of interaction between irrigation treatments and nitrogen fertilizer rates on yield of plant (g) at harvest time.

Combined analysis of 1991, 1992 and 1993 seasons

Irrigation treat. / N rates (kg/fed.)	Normal irrigation	Skipping 3rd+4th irrigations	Skipping 3rd+5th irrigations	Skipping 3rd+6th irrigations	Skipping 4th+5th irrigations	Skipping 4th+6th irrigations	Skipping 5th+6th irrigations
Zero	17.97A b	17.01ABb	17.03ABab	16.13ABb	14.86B b	18.76A a	17.82A bc
15	20.82A a	16.91B b	18.36ABa	19.19ABa	18.68ABa	19.80A a	21.23A a
30	20.19A a	19.59A a	16.07B ab	18.68A ab	18.83A a	18.84A a	21.26A a
45	21.90A a	20.25ABa	18.49B a	18.05B ab	18.17B a	18.58B a	19.92ABab
60	19.34A ab	16.66ABa	14.93B b	16.88ABab	17.43ABa	17.48ABa	16.19B c

Seed yield per fed.:

Seed yield (kg/fed.) was affected significantly by the interaction between irrigation treatments and nitrogen fertilizer as shown in Table (19). Nitrogen fertilizer rates did not affect significantly seed yield per fed. by normal irrigation or skipping 3rd+6th or 4th+6th irrigations. Seed yield per fed. increased significantly by adding 45 kg N/fed. and skipping 3rd+4th, 3rd+5th and 4th+5th irrigations, respectively as compared with the control treatment. With skipping 5th + 6th irrigations, application of 60 kg N/fed. increased the seed yield per feddan significantly compared to the unfertilized control and insignificant over the other rates. Seed yield per fed. reached its maximum weight (1059.41 kg/fed.) at normal irrigation and 45 kg N/fed., the minimum weight (740.83 kg/fed.) was obtained by skipping 3rd+4th irrigations and zero level of nitrogen. It seems that skipping the third and fourth irrigations is more effective on seed yield of soybean plant over nitrogen fertilizer rates used in our study. The decrease in seed yield per fed. by skipping 3rd+4th irrigations over nitrogen fertilizer used may be due to the decrease in weight of pods for the same treatments.

C- Chemical contents:

The effect of the interaction between irrigation treatments and nitrogen fertilizer rates on chlorophyll "a", "b", total chlorophyll, carotenoides as well as oil, protein, carbohydrate, nitrogen, phosphorus and potassium percentages in soybean seeds and protein yield (kg/fed.) were not statistically significant. Consequently the data were excluded.

Table (19): Effect of interaction between irrigation treatments and nitrogen fertilizer rates on seed yield (kg/fed.) at harvest time.

Combined analysis of 1991, 1992 and 1993 seasons

Irrigation treat. / N rates (kg/fed.)	Normal irrigation	Skipping 3rd+4th irrigations	Skipping 3rd+5th irrigations	Skipping 3rd+6th irrigations	Skipping 4th+5th irrigations	Skipping 4th+6th irrigations	Skipping 5th+6th irrigations
Zero	1041.91A a	740.83D b	748.83CDc	858.83BCa	774.16CDc	938.83ABa	910.50B b
15	970.25ABa	860.50B a	883.33B ab	902.50ABa	891.33ABb	922.16ABa	1007.75A ab
30	1000.50A a	827.16B ab	942.16ABa	945.50ABa	960.83A ab	888.33ABa	941.91ABab
45	1059.41A a	923.33B a	955.00ABa	922.50B a	1023.58ABa	1032.52ABa	990.00ABab
60	1056.66A a	845.00CDab	807.75D bc	925.00BCa	924.41BCab	942.75ABCa	1040.00ABa

Oil yield:

The effect of interaction between irrigation treatments and nitrogen fertilizer affected significantly oil yield (kg/fed.) as a combined analysis of 1991, 1992 and 1993 seasons as shown in Table (20). Nitrogen rates did not affect significantly oil yield by normal irrigation as well as skipping 3rd+6th, 4th+6th, 5th+6th irrigations as shown in Table (20). Oil yield increased significantly at nitrogen rate of 45 kg N/fed. and skipping each of 3rd+4th, 3rd+5th and 4th+5th irrigations. With regard to irrigation treatments it could be noticed that skipping irrigation did not affect oil yield per fed. at the rates of 15, 30 and 45 kg N/fed.. Oil yield per fed. decreased significantly at zero level and 60 kg N/fed. with skipping 3rd+5th irrigations. Decreasing oil yield per fed. may be due to the decrease in seed yield as a result of skipping 3rd+5th irrigations with 60 kg N/fed. (Table, 19). Overall interaction data, oil yield per fed. reached its maximum peak (226.61 kg/fed.) by adding 45 kg N/fed. and normal irrigation, whereas the minimum value (154.77 kg/fed.) was obtained by zero level of nitrogen and skipping 3rd+5th irrigations. The increase in oil yield per fed. may be due to the increase in seed yield by normal irrigation and 45 kg N/fed. as shown in Table (19).

Table (20): Effect of interaction between irrigation treatments and nitrogen fertilizer rates on oil yield (kg/fed.) at harvest time.

Combined analysis of 1991, 1992 and 1993 seasons

Irrigation treat. / N rates (kg/fed.)	Normal irrigation	Skipping 3rd+4th irrigations	Skipping 3rd+5th irrigations	Skipping 3rd+6th irrigations	Skipping 4th+5th irrigations	Skipping 4th+6th irrigations	Skipping 5th+6th irrigations
Zero	208.60A a	167.17CDb	154.77D b	181.26ABCDa	171.02BCDb	203.92ABa	199.87ABCa
15	205.00A a	194.50A ab	183.34A ab	196.51A a	189.73A ab	192.13A a	218.17A a
30	206.30A a	170.93A ab	188.35A ab	188.95A a	194.88A ab	191.08A a	187.90A a
45	226.61A a	203.41A a	192.71A a	195.95A a	220.75A a	213.26A a	204.22A a
60	226.45A a	181.54BCab	162.46C ab	214.57ABa	205.71ABa	195.81ABa	216.86ABa

Second experiment:

The second experiment in this work included 10 treatments which were the combination of two bacterial inoculation treatments (uninoculation, inoculation) and 5 levels of nitrogen fertilizer (zero, 15, 30, 45 and 60 kg N/fed.).

I- Effect of bacterial inoculation:

A- Growth:

Effect of bacterial inoculation on growth characters of soybean plants in combined analysis of 1991, 1992 and 1993 seasons are shown in Table (21). Inoculation treatments affected significantly plant height and number of active, unactive and total nodules per plant. On the other hand, there was no significant differences in number of branches and leaves, leaf area, leaf area index and fresh and dry weight of leaves, stems, roots and total fresh and dry weight of soybean plant as a result of inoculation treatments.

1. Plant height:

Plant height increased by 13.44% as a result of inoculation seeds by Rhizobia than uninoculation treatment.

Many investigators came to the same conclusion (Nangiu, 1980; Bassiem, 1983 and Barsoum and Abdel-Gawad, 1990). They reported that soybean plant height increased significantly with inoculation as compared with control treatment (uninoculation).

Table (21): Effect of bacterial inoculation on growth characters of soybean plants after 55 days from planting.

Combined analysis of 1991, 1992 and 1993 seasons

Inoculation treatments	Plant height cm	No. of bran-ches/ plant	No. of leaves /plant	No. of nodules/plant			Leaf area/ plant cm^2	Leaf area index cm^2/cm^2	Fresh weight (g)				Dry weight (g)			
				Active	Un-active	Total			Leaves	Stems	Roots	Total	Leaves	Stems	Roots	Total
Uninoculation	42.10b	2.33a	10.34a	0.19b	0.06b	0.25b	1424.2a	4.74a	30.42a	14.96a	8.10a	53.48a	9.79a	4.89a	4.94a	19.62a
Inoculation	47.76a	2.37a	10.24a	17.52a	0.69a	18.21a	1432.9a	4.77a	29.16a	15.38a	8.41a	52.95a	10.07a	4.96a	5.03a	20.06a

2. Numbers of branches and leaves per plant:

There was a slight increase in number of branches and number of leaves of soybean plant by inoculation with Rhizobia, but the difference did not reach the 5% level of significance.

Similar results were obtained on number of branches by Hassan (1981), Dadson and Acquaah (1984) and Salwau (1989) who reported that inoculation treatments did not affect significantly number of branches per soybean plant. On the other hand, Bassiem (1983), Saad *et al.* (1983) and Hassanein (1987) showed that inoculation did not affect significantly number of leaves per soybean plant.

3. Number of nodules:

Inoculation with Rhizobia affected significantly each of number of active, unactive and total number of nodules per soybean plant as shown in Table (21). There was a significant decrease in active, unactive and total number of nodules by uninoculation treatment as compared by inoculation one. The reduction percentages were 98.41, 91.30 and 98.62% by uninoculation treatment than that of inoculation one for active, unactive and total number of nodules, respectively.

These results are in harmony with those reported by Nangiu (1980), Saad *et al.* (1983), Singh and Phillips (1983), Dadson and Acquaah (1984), Hassanein (1987) and El-Borai *et al.* (1988).

4. Leaf area and leaf area index:

There was a slight increase in leaf area and leaf area index per soybean plant by inoculation treatment, but without any significant differences as shown in Table (21).

Similar results were reported on soybean by Dadson and Acquaah (1984). They concluded that treating soybean seeds with *Rhizobium japonicum* inoculation gave an increase in leaf area and leaf area index.

5. Fresh weight:

Fresh weight of stems and roots increased by inoculation treatment than that of uninoculation treatment, whereas fresh weight of leaves and total fresh weight of soybean plant decreased by inoculation treatment than that of uninoculation treatment, but the differences did not reach the 5% level of significance (Table, 21).

6. Dry weight:

There was a slight increase in dry weight of leaves, stems, roots and total dry weight of soybean plant by inoculation but the differences did not reach the 5% level of significance as shown in Table (21).

Similar results on soybean were obtained by Hassanein (1987) who found that dry weight of roots, stems, leaves and whole plant were not significant under nodulation treatments.

On the other hand, Abel and Erdman (1964), Ashour *et al.* (1969), Singh and Saxena (1973), Bhangoo and Albritton (1976), Hamdi *et al.* (1981), El-Essawi and Abadi (1985), Dadson and Acquaah (1984) and Chandel *et al.* (1988) showed that inoculation with Rhizobia increased significantly fresh and dry weight of soybean plant.

It could be concluded that inoculation soybean with Rhizobia increased most of growth characters as shown in Table (21). This result is to be expected because there was a positive relationship between number of nodules and the amount of nitrogen fixation. The increases in growth characters of soybean plant which studied in the scope of our study may be attribute to the favourable effect of nodulation of soybean plants, which in turn resulted in higher fixed amount of nitrogen.

B- Yield and yield components:

Table (22) shows the effect of bacterial inoculation treatments on number of pods, weight of pods, number of seeds per pod, weight of 100-seed and yield of plant as combined analysis of 1991, 1992 and 1993 seasons.

Bacterial inoculation treatments affected significantly number of pods, weight of pods and yield of soybean plant. On the other hand, it did not affect significantly number of seeds per pod and weight of 100-seed.

Table (22): Effect of bacterial inoculation on yield and yield components of soybean plants at harvest time.

Combined analysis of 1991, 1992 and 1993 seasons

Inoculation treatments	No. of pods/ plant	Weight of pods/plant (g)	No. of seeds/pod	Weight of 100-seed (g)	Yield of plant (g)	Seed yield (kg/fed.)	Biological yield (kg/fed.)
Uninoculation	46.71b	30.77b	2.82a	16.06a	17.91b	852.86b	3012.43b
Inoculation	54.28a	34.55a	2.80a	16.69a	20.22a	1097.60a	3778.10a

1. Number of pods per plant:

Number of pods per soybean plant increased significantly by inoculation treatment than that of uninoculation one. The reduction percentage in number of pods per plant was 13.94% by uninoculation as compared with inoculation treatment as shown in Table (22).

Similar results reported by Ashour *et al.* (1969), Hassan (1981), Hassanein (1987) and Barsoum and Abdel-Gawad (1990) who indicated that Rhizobium inoculation affected significantly number of pods per soybean plant.

2. Weight of pods per plant:

Bacterial inoculation treatments affected significantly weight of pods per soybean plant. Weight of pods increased significantly by inoculation than that of uninoculation treatment. The increase percentage in weight of pods per plant was 12.28% by inoculation as compared with uninoculation treatment as shown in Table (22).

These results are in accordance with those obtained by Salwau (1989).

3. Number of seeds per pod:

Number of seeds per pod was not affected significantly by bacterial inoculation treatments as shown in table (22).

These results are in good accordance to those reported on soybean by El-Borai *et al.* (1988) and Barsoum and Abdel-Gawad

(1990). They confirmed that inoculation treatments did not affect significantly number of seeds per pod.

4. Weight of 100-seed:

Weight of 100-seed was not affected by inoculation treatments. In this respect Abdalla (1983) came to similar result. On the other hand, Hammam (1986), El-Borai *et al.* (1988), Salwau (1989), Barsoum and Abdel-Gawad (1990), Salama and Ghonema (1990) and Sharaf and Salwau (1992) came to opposite results.

5. Weight of seeds per plant:

Bacterial inoculation treatments affected significantly yield of soybean plant. Yield of plant increased significantly by inoculation than the uninoculation treatment. The increase percentage in yield of plant was 12.89% by inoculation as compared with uninoculation treatment (Table, 22).

Similar results on soybean reported by Ashour *et al.* (1969), Hassan (1981), Hammam (1986), El-Borai *et al.* (1988), Salwau (1989), Barsoum and Abdel-Gawad (1990) and Sharaf and Salwau (1992).

6. Yield:

Inoculation treatments affected significantly seed yield as well as biological yield per fed. as shown in Table (22). Seed yield and biological yield increased significantly by inoculation treatment than the uninoculation. The reduction percentage in

seed yield and biological yield as a result of uninoculation were 22.29 and 20.26%, respectively as compared with inoculation treatment. Increasing seed yield per fed. as a result of inoculation is to be expected since inoculation increased weight of pods per soybean plant.

Generally, it could be concluded that inoculation with *Rhizobium japonicum* increased significantly number as well as weight of pods per plant, yield per plant, seed yield and biological yield per fed.. It is clear from Table (21) that inoculation increased number of active nodules per soybean plant. The increase in number as well as weight of pods per plant, seed yield and biological yield per fed. is to be expected since inoculation led to a successful nodulation and consequently an active N fixation in soybean.

These results are in harmony with those obtained by Abel and Erdman (1964), Raitshewa (1967), Karbachsch (1972), Bhangoo and Albritton (1975), Nangiu (1980), Hassan (1981), Sekhon *et al.* (1984), Hammam (1986), Chandel *et al.* (1988), El-Borai *et al.* (1988), Salwau (1989), Barsoum and Abdel-Gawad (1990) and Salama and Ghonema (1990).

C- Chemical contents:

The results of the combined analysis of 1991, 1992 and 1993 seasons which are reported in Table (23) shows that chlorophyll "b" was affected significantly, whereas chlorophyll "a", total

Table (23): Effect of bacterial inoculation on photosynthesis pigments in soybean leaves after 55 days from planting.

Combined analysis of 1991, 1992 and 1993 seasons

Inoculation treatments	Pigments in mg/100 g fresh weight			
	Chlorophyll "a"	Chlorophyll "b"	Chlorophyll "a+b"	Carotenoides
Uninoculation	294.55a	152.71a	447.26a	186.98a
Inoculation	287.82a	144.63b	432.45a	189.81a

chlorophyll "a+b" and carotenoides was not affected significantly by bacterial inoculation treatments. Chlorophyll "a" increased by inoculation, but the difference was not great enough to reach the 5% level of significance.

Chlorophyll "b" increased significantly by uninoculation than the inoculation treatment. The increase percentage in chlorophyll "b" was 5.58% by uninoculation as compared with inoculation treatment as shown in Table (23). There was a slight decrease in total chlorophyll (a+b) as a result of inoculation and this may be due to the reduction in chlorophyll "a" and "b" as shown in Table (23). There was a slight increase in carotenoides by inoculation with Rhizobia, but the differences did not reach the 5% level of significance.

Table (24) shows the effect of bacterial inoculation treatments on chemical contents of soybean seeds as a combined analysis of 1991, 1992 and 1993 seasons. Bacterial inoculation treatments did not affect significantly oil percentage, protein percentage, carbohydrate percentage, nitrogen percentage, phosphorus percentage and potassium percentage as shown in Table (24). However, there was a slight decrease in oil percentage, carbohydrate percentage and phosphorus percentage as result of inoculation. On the other hand, there was a slight increase in nitrogen percent as well as protein percent by inoculation treatment. This result is to be expected since inoculation increased number of active nodules per plant.

Table (24): Effect of bacterial inoculation on Chemical contents of soybean seeds.

Combined analysis of 1991, 1992 and 1993 seasons

Inoculation treatments	Oil %	Oil yield (kg/fed.)	Protein %	Protein yield (kg/fed.)	Carbohy-rates %	N %	P %	K %
Uninoculation	22.54a	190.79b	31.42a	265.78b	15.44a	5.03a	0.609a	1.896a
Inoculation	21.38a	234.41a	32.54a	356.58a	15.36a	5.21a	0.585a	1.006a

In this connection, Ashour *et al.* (1969), Varma and Tiwari (1976), Hamdi *et al.* (1981), Abdalla (1983), Bassiem (1983), Kamel *et al.* (1983), Pahalwan and Tripathi (1984), Hassanein (1987), El-Borai *et al.* (1988) and Salwau (1989) come to similar results.

Oil yield (kg/fed.) was affected significantly by bacterial inoculation treatments as shown in Table (24). Oil yield per fed. increased significantly by inoculation than the uninoculation. The reduction percentage in oil yield per fed. was 18.60% by uninoculation as compared with inoculation treatment. These results may be due to the increase in soybean yield by inoculation treatment (Table, 22).

Similar results were obtained by Kamel *et al.* (1983) who reported that Rhizobium inoculation had a significant increase on oil yield of soybean per fed..

Bacterial inoculation treatment affected significantly protein yield (kg/fed.) of soybean as shown in table (24). Protein yield per fed. increased significantly by inoculation than the uninoculation treatment. The increase percentage in protein yield per fed. was 34.16% by inoculation as compared with uninoculation treatment. The increase in protein per fed. may be due to the increase in protein percentage as well as seed yield per fed. (Table, 22).

These results are in a good agreement with those reported by Kamel *et al.* (1983) and Salwau (1989) who concluded that

inoculation increased significantly protein yield per fed. of soybean.

II- Effect of nitrogen fertilizer:

A- Growth characters:

Effect of nitrogen fertilizer on growth characters of soybean plant in combined analysis of 1991, 1992 and 1993 seasons is shown in Table (25). It is quite clear from Table (25) that nitrogen fertilizer rates affected significantly number of unactive nodules per plant, fresh and dry weight of roots per plant. On the other hand, nitrogen rates did not affect the other growth characters in our study.

1. Plant height, numbers of branches and leaves per plant:

Plant height, number of branches and number of leaves ranged from 44.41 to 45.70 cm, 2.23 to 2.46 and 9.83 to 10.93, respectively. The differences did not reach the 5% level of significance.

Similar results were obtained by Abdel-Hafeez (1970), Hassan (1981), Thalooth *et al.* (1983), Hassanein (1987) and Salwau (1989).

2. Number of nodules:

Active nodules per soybean plant decreased by 3.19/plant as a result of increasing nitrogen rate from 15 to 60 kg N/fed., the difference was not significant. There was a consistent and

Table (25): Effect of nitrogen fertilizer rates on growth characters of soybean plants after 55 days from planting.

Combined analysis of 1991, 1992 and 1993 seasons

Nitrogen rates (Kg/fed.)	Plant height cm	No. of branches/ plant	No. of leaves /plant	No. of nodules/plant			Leaf area/ plant cm^2	Leaf area index cm^2/cm^2	Fresh weight (g)				Dry weight (g)			
				Active	Un-active	Total			Leaves	Stems	Roots	Total	Leaves	Stems	Roots	Total
Zero	45.31a	2.23a	9.83a	9.00a	0.54a	9.54a	1477.5a	4.92a	28.94a	15.24a	8.41ab	52.59a	10.00a	4.99a	5.10ab	20.09a
15	44.68a	2.36a	10.33a	10.63a	1.31b	10.94a	1522.0a	5.07a	30.18a	14.76a	8.23ab	53.17a	9.92a	4.77a	5.06ab	19.75a
30	45.70a	2.46a	10.95a	8.71a	0.19c	8.90a	1426.0a	4.75a	31.39a	15.98a	8.92a	56.29a	10.63a	5.14a	5.41a	21.18a
45	44.41a	2.41a	10.45a	8.53a	0.18d	8.71a	1371.7a	4.57a	29.49a	14.93a	7.95b	52.37a	9.63a	4.82a	4.55c	19.00a
60	44.55a	2.29a	9.90a	7.44a	0.60a	8.04a	1345.4a	4.48a	28.95a	14.93a	7.77b	51.65a	9.45a	4.91a	4.81bc	19.17a

significant decrease in number of unactive nodules by increasing nitrogen level up to 45 kg N/fed.. Active and total numbers of nodules per plant reached its maximum peak by adding 15 kg N/fed., whereas it reached its minimum peak by adding 60 kg N/fed., without any significance differences. These results may be due to that soybean is a leguminous crop which needs a small amount of nitrogen at the first period of growth. Increasing nitrogen rates up to 60 kg N/fed. may inhibit symbiosis bacteria.

In this respect, Weber (1966b), Beard and Hoover (1971), Ham *et al.* (1975), Bassiem (1983) and Katach *et al.* (1983). Beard and Hoover (1971) found that nodule number per soybean roots was linearly and inversely related to rate of nitrogen application. There were fewer nodules per plant if 56 kg N/ha. or more nitrogen was applied at planting time, increasing N up to 112 kg N/ha. did not affect nodule numbers if applied at flowering. Ham *et al.* (1975) indicated that all sources of fertilizer decreased N2 fixation, nodule number of soybean. Bassiem (1983) showed that nitrogen fertilizer at low level, i.e. 15 kg N/fed. resulted in increasing number of nodules per soybean plant, whereas such number of nodules was decreased by increasing nitrogen rates up to 45 kg N/fed.. Katach *et al.* (1983) stated that maximum number of nodules per soybean plant was obtained by the treatment of 30 kg N/fed..

3. Leaf area and leaf area index:

Leaf area and leaf area index per soybean plant were not affected by nitrogen leaves, but its values increased by the rate of

15 kg N/fed. as compared with zero level and without any significance differences as shown in Table (25).

In this respect, Ashoub *et al.* (1992) found that the addition of nitrogen caused slight increase in leaf area per soybean plant. Kassab (1993) showed that nitrogen fertilizer levels of 10, 20 and 30 kg N/fed. exhibited no significant difference in leaf area index of soybean at 55 days from planting.

4. Fresh weight:

Nitrogen fertilizer rates had no significant effect on fresh weight of leaves, stems and total weight of plant. Weight of leaves, stems and total weight of plant ranged from 28.94 to 31.39 g for leaves, 14.93 to 15.98 g for stems and 51.65 to 56.29 g for total fresh weight as shown in Table (25). On the other hand, nitrogen rates affected significantly fresh weight of roots per plant. Fresh weight of roots increased significantly by adding nitrogen fertilizer up to 30 kg N/fed.. Further increase in nitrogen rates decreased weight of roots per plant. Weight of roots reached its maximum weight by adding 30 kg N/fed., whereas it reached its minimum weight by adding 60 kg N/fed..

These results are in agreement with those reported by Hathcock (1975) who found that no significant differences in fresh weight of soybean plant was obtained by 0.0, 16.0 or 24.0 Lb N/ac. treatments. Kassab (1993) stated that at 55 days after planting, leaves fresh weight of soybean plant increased with increasing N level up to 20 kg N/fed., but the difference was not

significant. He added that increasing N level increased significantly fresh weight of roots.

5. Dry weight:

Data in Table (25) elucidate that dry weight of leaves, stems and total dry weight per soybean plant were not affected significantly by nitrogen fertilizer. Whereas, nitrogen fertilizer levels affected significantly dry weight of roots per plant. Dry weight of roots increased significantly by increasing nitrogen rates up to 30 kg N/fed.. Further increase in nitrogen rates decreased weight of roots per plant. The differences in weight of roots per plant as affected by nitrogen fertilizer were not significant between zero, 15 and 60 kg N/fed., as well as between 45 and 60 kg N/fed. as shown in Table (25). Weight of roots per plant reached its maximum weight by adding 30 kg N/fed., whereas it reached its minimum weight by adding 45 kg N/fed..

These results are in harmony with those obtained by Hathcock (1975), Samepet (1978), Saad *et al.* (1983) and Kassab (1993).

B- Yield and yield components:

Effect of nitrogen fertilizer rates on yield components of soybean plant in combined analysis of 1991, 1992 and 1993 seasons are shown in Table (26). It is quite clear from Table (26) that nitrogen fertilizer affected significantly number of pods, weight of pods and yield per soybean plant. On the other hand,

Table (26): Effect of nitrogen fertilizer rates on yield and yield components of soybean plants at harvest time.

Combined analysis of 1991, 1992 and 1993 seasons

Nitrogen rates (kg/fed.)	No. of pods/ plant	Weight of pods/plant (g)	No. of seeds/pod	Weight of 100-seed (g)	Yield of plant (g)	Seed yield (kg/fed.)	Biological yield (kg/fed.)
Zero	46.14c	28.51b	2.73a	15.89a	17.32b	887.75c	3144.16c
15	49.69bc	34.74a	2.74a	16.54a	20.58a	971.79b	3313.87bc
30	53.80ab	34.97a	2.82a	16.73a	19.85a	1035.79a	3572.62ab
45	54.81a	34.64a	2.87a	16.63a	20.30a	1070.00a	3708.33a
60	48.04c	30.45b	2.86a	16.08a	17.29b	910.83c	3237.33c

nitrogen rates did not affect number of seeds per pod and weight of 100-seed..

1. Number of pods per plant:

Number of pods per soybean plant was affected significantly by nitrogen levels. Number of pods increased significantly by adding nitrogen fertilizer up to 45 kg N/fed.. There was no significant difference in number of pods between 15 and 30 kg N/fed. as well as between zero, 15 and 60 kg N/fed.. Number of pods per plant reached its maximum value at 45 kg N/fed., whereas it reached its minimum value at zero level of nitrogen. The difference in number of pods per plant between maximum and minimum values was 8.67 pods/plant.

These results coincide with the findings of Bassiem (1983), Haggag *et al.* (1984), Sharaf (1984), Hammam (1986) and Salwau (1989). They concluded that nitrogen fertilizer increased number of pods per soybean plant.

2. Weight of pods per plant:

Nitrogen fertilizer affected significantly weight of pods per soybean plant as shown in Table (26). Weight of pods per plant increased to its maximum weight by adding 30 kg N/fed., whereas the minimum weight obtained at zero level of nitrogen. There was no significant difference in weight of pods per plant between 15, 30 and 45 kg N/fed. as well as between zero and 60 kg N/fed.. Increasing pods weight as a result of increasing nitrogen rate may be due to the increase in number of pods per plant.

5. Yield:

Concerning seed yield (kg/fed.) of soybean, data reported in Table (26) demonstrate that nitrogen levels affected significantly seed yield per fed.. Seed yield per fed. increased as nitrogen fertilizer increased up to 30 kg N/fed.. Seed yield per fed. reached its maximum peak by adding 45 kg N/fed., whereas it reached its minimum peak by zero level of nitrogen. Seed yield per fed. increased by 84.04, 148.04, 182.25 and 23.08 kg by adding 15, 30, 45 and 60 kg N/fed., respectively as compared with the control (zero-N). The difference in seed yield per fed. between 30 and 45 kg N/fed. was not significant as well as between zero and 60 kg N/fed.. Increasing seed yield per fed. as a result of increasing nitrogen levels may be due to the increase of seed yield per plant.

Many investigators came to the same conclusion, Lawn and Brun (1974), Bhangoo and Albritton (1976), Brevedan *et al.* (1978), Eisa (1980), Sharaf (1980), Dubetz *et al.* (1983), Hassan *et al.* (1985) and Salwau (1989). They concluded that nitrogen rates increased significantly seed yield of soybean per fed..

Nitrogen fertilizer rates affected significantly biological yield of soybean (Kg/fed.) as shown in Table (26). Biological yield per fed. increased by increasing nitrogen levels up to 30 kg N/fed.. Further increase in nitrogen levels up to 60 kg N/fed. decreased biological yield. Biological yield per fed. increased by 428.46 and 564.17 kg/fed. at 30 and 45 kg N/fed., respectively as compared with zero-level of nitrogen. The difference in biological yield per fed. between 15 and 30 kg N/fed. as well as between zero, 15 and

60 kg N/fed. were not significant. The increase in biological yield by appling nitrogen fertilizer may be due to the increase in seed yield per fed..

Similar results were obtained by Sharaf (1980), Abdel-Gawad *et al.* (1983), Osman (1985) and Kassab (1993).

Generally, it could be stated that nitrogen fertilizer rate up to 30 kg N/fed. increased significantly number of pods per plant, weight of pods per plant, seed yield and biological yield per fed.. In addition, there was a considerable and consistent increase these traits as nitrogen fertilizer increased from zero up to 30 kg N/fed.. These results clear the essential role of nitrogen in growth as well as yield of soybean plant. It seems from our study that nitrogen fertilizer rate up to 30 kg N/fed. is essential for increasing yield as well as yield components of soybean plant. Increasing nitrogen fertilizer up to 45 kg N/fed. did not affect number of pods, weight of pods per plant, seed yield as well as biological yield of soybean as compared with 30 kg N/fed..

C- Chemical contents:

The results presented in Table (27) concluded clearly that photosynthetic pigments of soybean leaves i.e. chlorophyll "a", "b", total chlorophyll "a+b" and carotenoides were affected significantly by nitrogen fertilizer rates.

Table (27): Effect of nitrogen fertilizer rates on photosynthesis pigments in soybean leaves after 55 days from planting.

Combined analysis of 1991, 1992 and 1993 seasons

Nitrogen rates (kg/fed.)	Pigments in mg/100 g fresh weight			
	Chlorophyll "a"	Chlorophyll "b"	Chlorophyll "a+b"	Carotenoides
Zero	270.00c	138.37b	408.37c	183.66bc
15	293.95b	144.39b	438.34b	188.40bc
30	310.93a	158.54a	469.47a	200.59a
45	290.48b	156.97a	447.45a	179.05c
60	290.57b	145.05b	435.62b	190.25b

results obtained on seed yield as well as biological yield per fed. (Table, 26).

This conculsion was supported by Ali (1981), Yakout *et al.* (1981), Osman (1985) and Hassanein (1987).

Nitrogen fertilizer rates did not affect significantly oil, protein, carbohydrate, nitrogen, phosphorus and potassium percentages as shown in Table (28). Oil percentage ranged from 21.5 to 22.22% and carbohydrate percentage ranged from 15.10 to 16.19%. The difference in protein percentage between maximum and minimum percent was 4.74% without any significance difference.

These results agree with the results obtained by Nur (1977), Samepet (1978), Ali (1981), Bassiem (1983), Hammam (1986), Ashoub *et al.* (1992) and Kassab (1993). They concluded that nitrogen fertilizer rates did not affect this traits.

Oil yield (kg/fed.) was affected significantly by nitrogen fertilizer rates as shown in Table (28). Oil yield increased by increasing nitrogen rates up to 30 kg N/fed.. Oil yield reached its maximum weight by adding 45 kg N/fed., whereas it reached its minimum weight by zero level of nitrogen. The difference in oil yield between 30 and 45 kg N/fed. as well as between 15 and 30 kg N/fed. were not significant. This result is to be expected because seed yield increased as nitrogen increased up to 45 kg N/fed. (Table, 26).

Chlorophyll "a", "b" and total chlorophyll "a+b" increased significantly by increasing nitrogen fertilizer level up to 30 kg N/fed.. Further increase in nitrogen rate up to 60 kg N/fed. decreased its values. Chlorophyll "a", "b" and total chlorophyll "a+b" reached its maximum values by adding 30 kg N/fed., whereas it reached its minimum values by zero level of nitrogen. Chlorophyll "a", "b" and total chlorophyll "a+b" increased by 15.15, 14.57 and 14.96% by adding 30 kg N/fed., respectively as compared with the control. There was no significant difference in chlorophyll "b" between 30 and 45 kg N/fed. as well as between zero, 15 and 60 kg N/fed.. Whereas there was no significant difference in total chlorophyll "a+b" between 30 and 45 kg N/fed. as well as between 15 and 60 kg N/fed..

With regard to carotenoides, it could be shown from Table (27) that it increased as nitrogen increased up to 30 kg N/fed.. Further increase in nitrogen rate up to 60 kg N/fed. decreased carotenoides. Carotenoides reached its maximum peak by adding 30 kg N/fed., whereas it reached its minimum peak by adding 45 kg N/fed.. The difference in carotenoides between zero, 15 and 60 kg N/fed. as well as between zero, 15 and 45 kg N/fed. were not significant. It could be concluded that nitrogen fertilizer rate up to 30 kg N/fed. increased photosynthetic pigments in soybean leaves. There was a considerable and consistent increase in photosynthetic pigments as nitrogen fertilizer increased from zero to 30 kg N/fed.. Increasing nitrogen fertilizer up to 60 kg N/fed. did not affect significantly the photosynthetic pigments. This result confirms the

Table (28): Effect of nitrogen fertilizer rates on Chemical contents of soybean seeds.

Combined analysis of 1991, 1992 and 1993 seasons

Nitrogen rates (kg/fed.)	Oil %	Oil yield (kg/fed.)	Protein %	Protein yield (kg/fed.)	Carbohy-rates %	N %	P %	K %
Zero	22.11a	192.02d	28.53a	253.90c	16.19a	4.58a	0.590a	1.897a
15	22.08a	215.61bc	32.36a	320.25ab	15.10a	5.21a	0.621a	1.925a
30	21.50a	220.26ab	33.27a	342.20a	15.27a	5.32a	0.625a	1.912a
45	21.91a	235.05a	32.77a	345.71a	15.37a	5.24a	0.590a	1.872a
60	22.22a	200.06cd	32.96a	293.79b	15.16a	5.27a	0.558a	1.870a

Similar results were obtained by Fayed *et al.* (1986) who found that increasing nitrogen rates caused significant increase in oil yield of soybean per fed.. Abdel-Ghany (1988) concluded that crude oil yield of soybean per fed. was increased consistently as N levels was increased with significant differences between N application levels. Kassab (1993) observed that increasing nitrogen fertilizer up to 20 kg N/fed. increased oil yield (kg/fed.) of soybean as compared with the other treatments.

With regard to protein yield of soybean (kg/fed.), data in Table (28) indicate that protein yield increased significantly by increasing nitrogen fertilizer rates up to 15 kg N/fed.. Protein yield per fed. increased by 66.35, 88.30, 91.81 and 39.89 kg by adding 15, 30, 45 and 60 kg N/fed., respectively as compared with the control (zero-N). Protein yield (kg/fed.) came to its maximum value by adding 45 kg N/fed. without any significant difference with 15 and 30 kg N/fed., whereas it came to its minimum value by zero level of nitrogen. The differences in protein yield between 15 and 60 kg N/fed. were not significant. This result is to be expected since seed yield as well as protein percentage increased at a rate of 45 kg N/fed..

The present results are in accordance with the results obtained by Ham *et al.* (1975), Abdalla (1983), Ashour and Thalooth (1983), El-Sayed *et al.* (1984), Fayed *et al.* (1986), Abdel-Ghany (1988) and Kassab (1993).

III- Effect of interaction:

A- Growth characters of soybean plant:

The effect of interaction between bacterial inoculation and nitrogen fertilizer rates on all growth characters was not statistically significant. Consequently, the data were excluded.

B- Yield and yield components:

The effect of interaction between bacterial inoculation and nitrogen fertilizer rates on weight of pods per plant, number of seed per pod and biological yield of soybean (kg/fed.) was not statistically significant, showing that each of the two factors act independently on these characters. Consequently the data were excluded.

Number of pods per plant:

Number of pods per plant was significantly affected by the interaction between bacterial inoculation and nitrogen fertilizer rates as a combined analysis of 1991, 1992 and and 1993 seasons as shown in Table (29). With regard to nitrogen fertilizer rates it is clear from Table (29) that nitrogen rates affected number of pods per soybean plant up to 45 kg N/fed. under inoculation treatment, whereas it increased to its maximum value under uninoculation treatment at a rate of 60 kg N/fed.. On the other hand, inoculation treatment increased number of pods per soybean plant under zero, 15 and 45 kg N/fed. whereas uninoculation treatment increased number of pods per plant than that of inoculation under 60 kg N/fed. Number of pods per plant increased

Table (29): Effect of the interaction between bacterial inoculation and nitrogen fertilizer rates on number of pods per plant at harvest time.

Combined analysis of 1991, 1992 and 1993 seasons

Inoc. treatments / N rates (kg/fed.)	Uninoculation	Inoculation
Zero	39.04B b	53.25A b
15	43.06B b	56.33A b
30	51.71A a	55.88A b
45	43.92B b	65.71A a
60	55.77A a	40.26B c

to its maximum number (65.71) at inoculation and 45 kg N/fed., whereas it came to its minimum number (39.04) at uninoculation and zero-N. The increase percent between the two values was 68.31%. These results suggest that inoculation with *Rhizobium japonicum* as well as dose of nitrogen fertilizer of 45 kg N/fed. is more effective on number of pods per soybean plant.

Weight of 100 seeds:

The effect of interaction between bacterial inoculation and nitrogen fertilizer rates affected significantly weight of 100 seeds as a combined analysis of 1991, 1992 and 1993 seasons as shown in Table (30). With regard to bacterial inoculation, it is quite clear from Table (30) that inoculation treatment increased weight of 100 seeds under each of zero and 15 kg N/fed.. Bacterial inoculation did not affect weight of 100-seeds under 30, 45 and 60 kg N/fed.. On the other hand, nitrogen fertilizer up to 15 and 45 kg N/fed. increased significantly weight of 100 seeds under inoculation and uninoculation treatment respectively. Weight of 100 seeds came to its minimum weight at zero level of nitrogen and uninoculation, whereas it reached its maximum weight at 15 kg N/fed. and inoculation treatment. The increase percentage between the two values was 14.80%.

Yield of plant:

The interaction between bacterial inoculation and nitrogen fertilizer rates affected significantly yield of soybean plant as shown in Table (31). With regard to bacterial inoculation, it could

Table (30): Effect of the interaction between bacterial inoculation and nitrogen fertilizer rates on weight of 100-seed (g).

Combined analysis of 1991, 1992 and 1993 seasons

Inoc. treatments / N rates (kg/fed.)	Uninoculation	Inoculation
Zero	15.27B c	16.52A ab
15	15.55B b	17.53A a
30	16.51A ab	16.94A ab
45	16.95A a	16.33A b
60	16.02A abc	16.14A b

Table (31): Effect of the interaction between bacterial inoculation and nitrogen fertilizer rates on yield of plant (g).

Combined analysis of 1991, 1992 and 1993 seasons

Inoc. treatments / N rates (kg/fed.)	Uninoculation	Inoculation
Zero	14.03B c	20.61A a
15	21.10A a	20.05A a
30	18.47B b	21.23A a
45	18.45B b	22.14A a
60	17.49A b	17.09A b

be shown from Table (31) that bacterial inoculation increased seed yield of soybean plant under zero, 30 and 45 kg N/fed., whereas it did not affect yield of plant under 15 and 60 kg N/fed.. On the other hand, nitrogen fertilizer rate of 60 kg N/fed. decreased yield of plant under inoculation treatment whereas it increased significantly at a rate of 15 kg N/fed. under uninoculation treatment. There was no significant difference between zero, 15, 30 and 45 kg N/fed. under inoculation treatment as well as between 30, 45 and 60 kg N/fed. under uninoculation treatment. Seed yield per soybean plant reached its minimum value at zero level of nitrogen and uninoculation, whereas it reached its maximum yield at 45 kg N/fed. and inoculation treatment. The increase percentage between the two values was 57.80%.

Seed yield per fed.:

Seed yield (kg/fed.) was affected significantly by the interaction between bacterial inoculation and nitrogen fertilizer rates as shown in Table (32). With regard to bacterial inoculation, it is clear from Table (32) that seed yield increased significantly by bacterial inoculation than uninoculation one under all levels of nitrogen rates. It increased as a result of bacterial inoculation by 309.7, 346.42, 234.42, 196.67 and 136.08 kg/fed. under zero, 15, 30, 45 and 60 kg N/fed. as compared by uninoculation, respectively. This result clears the essential role of bacterial inoculation in increasing yield of soybean in spite of increasing nitrogen levels. With regard to nitrogen rates, seed yield per fed. decreased significantly at a rate of 60 kg N/fed. under inoculation

Table (32): Effect of the interaction between bacterial inoculation and nitrogen fertilizer rates on seed yield per feddan (kg).

Combined analysis of 1991, 1992 and 1993 seasons

Inoc. treatments / N rates (kg/fed.)	Uninoculation	Inoculation
Zero	732.75B c	1042.75A b
15	798.58B b	1145.00A a
30	918.58B a	1153.00A a
45	971.66B a	1168.33A a
60	842.75B b	978.83A c

and uninoculation treatments. There were no significant differences between 15, 30 and 45 kg N/fed. under inoculation treatment whereas the difference was not significant between 30 and 45 kg N/fed. under uninoculation one. Seed yield reached its maximum yield by inoculation and 45 kg N/fed., whereas it reached its minimum yield at zero level of nitrogen and uninoculation over all interaction data.

C- Chemical contents:

The effect of interaction between bacterial inoculation and nitrogen fertilizer rates on carotenoides and oil, protein, carbohydrate, nitrogen, phosphorus and potassium percentages in soybean seeds was not statistically significant. Consequently the data were excluded.

Chlorophyll "a":

The effect of interaction between bacterial inoculation and nitrogen fertilizer rates affected significantly chlorophyll "a" in soybean leaves after 55 days from planting as shown in Table (33). With regard to nitrogen fertilizer, chlorophyll "a" increased significantly by adding 15 kg N/fed. and inoculation as well as uninoculation treatments. With regard to nitrogen rates, chlorophyll "a" was not affected significantly by the rates of zero, 15 and 30 kg N/fed. under inoculation and uninoculation treatments. Whereas increasing nitrogen rate up to 45 kg N/fed. decreased chlorophyll "a" under inoculation treatment than that at uninoculation. Overall interaction data, it could be observed from

Table (33): Effect of the interaction between bacterial inoculation and nitrogen fertilizer rates on chlorophyll "a" (mg/100 g fresh weight) after 55 days from planting.

Combined analysis of 1991, 1992 and 1993 seasons

Inoc. treatments / N rates (kg/fed.)	Uninoculation	Inoculation
Zero	268.95A b	270.97A b
15	286.36A ab	301.54A a
30	306.04A a	315.83A a
45	308.40A a	272.55B b
60	302.84A a	278.22B b

Table (33) that chlorophyll "a" came to its maximum value by inoculation and 30 kg N/fed., whereas it reached its minimum value by uninoculation and zero-level of nitrogen.

Chlorophyll "b":

Chlorophyll "b" in soybean leaves after 55 days from planting was affected significantly by the interaction between bacterial inoculation and nitrogen fertilizer rates as shown in Table (34). With regard to bacterial inoculation under the levels of nitrogen, it is worthly to be noted that chlorophyll "b" behaved the same trend of chlorophyll "a". Nitrogen levels of zero, 15 and 30 kg N/fed. did not affect significantly chlorophyll "b" under neither inoculation nor uninoculation treatments. Bacterial inoculation decreased significantly chlorophyll "b" under 45 and 60 kg N/fed.. On the other hand, nitrogen fertilizer rate of 30 kg N/fed. increased significantly chlorophyll "b" under inoculation as well as uninoculation treatments. Increasing nitrogen rate up to 45 and 60 kg N/fed. decreased chlorophyll "b' under inoculation treatment, whereas it did not affect this trait under uninoculation treatment.

Oil yield:

The interaction between bacterial inoculation and nitrogen fertilizer rates affected significantly oil yield (kg/fed.) as shown in Table (35). Oil yield increased significantly by inoculation treatment than that of unincoulation under zero, 15, 30, 45 kg N/fed.. On the other hand, bacterial inoculation did not affect oil yield under 60 kg N/fed.. It could be shown from Table (35) that

Table (34): Effect of the interaction between bacterial inoculation and nitrogen fertilizer rates on chlorophyll "b" (mg/100 g fresh weight) after 55 days from planting.

Combined analysis of 1991, 1992 and 1993 seasons

Inoc. treatments / N rates (kg/fed.)	Uninoculation	Inoculation
Zero	137.95A c	138.79A b
15	143.63A bc	145.15A b
30	155.50A ab	161.50A a
45	170.52A a	143.42B b
60	155.89A ab	134.20B b

Table (35): Effect of the interaction between bacterial inoculation and nitrogen fertilizer rates on oil yield per feddan (kg).

Combined analysis of 1991, 1992 and 1993 seasons

Inoc. treatments / N rates (kg/fed.)	Uninoculation	Inoculation
Zero	162.45B c	221.60A bc
15	182.54B bc	248.67A a
30	200.26B ab	240.25A ab
45	218.33B a	251.76A a
60	190.36A b	209.75A c

increasing nitrogen rate up to 45 kg N/fed. increased significantly oil yield under inoculation and uninoculation treatments. Oil yield came to its maximum weight by adding 45 kg N/fed. under inoculation, whereas it reached its minimum weight by zero level of nitrogen under uninoculation. The difference between the two values were 89.31 kg/fed.. The increase in oil yield may be due to the increase in seed yield by inoculation and 45 kg N/fed. as shown in Table (32).

Protein yield:

Protein yield (kg/fed.) was affected significantly by the interaction between bacterial inoculation and nitrogen fertilizer rates as shown in Table (36). Results of protein yield as influenced by the interaction effect were along the same line of oil yield kg/fed.. Protein yield increased significantly with inoculation than that of uninoculation treatment under zero, 15, 30 and 45 kg N/fed.. Bacterial inoculation decreased protein yield under 60 kg N/fed.. With regard to nitroge: fertilizer, it could be noticed that nitrogen fertilizer rate of 15 kg N/fed. increased significantly protein yield than that of zero level under inoculation and uninoculation treatments. Increasing nitrogen rate to 30 and 45 kg N/fed. did not affect protein yield under the same two treatments of bacterial inoculation. Protein yield reached its maximum weight by adding 30 kg N/fed. under inoculation, whereas it reached its minimum weight by zero level of nitrogen under uninoculation treatment, the difference between the two

Table (36): Effect of the interaction between bacterial inoculation and nitrogen fertilizer rates on protein yield per feddan (kg).

Combined analysis of 1991, 1992 and 1993 seasons

Inoc. treatments / N rates (kg/fed.)	Uninoculation	Inoculation
Zero	203.34B b	304.57A b
15	253.37B ab	387.13A a
30	282.65B a	401.74A a
45	305.27B a	386.14A a
60	284.25A a	303.33A b

weights was 198.4 kg/fed.. The increase in protein yield per fed. may be due to the increase in seed yield per fed. by inoculation treatment and 30 kg N/fed. as shown in Table (32).

SUMMARY

SUMMARY

Two field experiments were conducted during 1991, 1992 and 1993 seasons at the Agricultural Research and Experiment Center of the Faculty of Agriculture at Moshtohor, Zagazig University, Egypt. The aims of this study were to determine the effect of some irrigation treatments, bacteria inoculation and nitrogen fertilizer on soybean productivity "Clark" variety. Clover was preceding winter crop in the three seasons.

First experiment:

To study the effect of some irrigation treatments and nitrogen fertilizer rates on growth, yield, yield components and chemical contents of soybean plants. It included 35 treatments which were the combinations of seven irrigation treatments (normal irrigation, skipping 3rd+4th or 3rd+5th or 3rd+6th or 4th+5th or 4th+6th or 5th+6th irrigations) and five rates of nitrogen fertilizer (zero, 15, 30, 45 and 60 kg N/feddan) as a urea fertilizer. The experiment was designed in a split plot design with four replications. The seven irrigation treatments were arranged at random in the main plots, whereas the five nitrogen fertilizer rates were alloted randomly in the sub plots. The sub plots area was 1/400 fed. (10.5 m^2).

The most important results could be summarized as follows:-