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PLANT GROWTH CHARACTERS OF FIELD GROWN ONION (*ALLIUM CEPA* L.) AS AFFECTED BY NITROGEN APPLICATION AND BIOFERTILIZERS INOCULATION

Barakat ,M.A.[1] , H.A. Elkhatib [2], S.M.Gabr[2] and E.A.Bedawy[3]
[1] Horticulture Dept., Faculty of Agric., Elfayom, Cairo University
[2] Horticulture Dept., Faculty of Agric., Damanhour, Alex. University
[3] Experts Dept., Ministry of Justice, Damanhour, El -Behira

ABSTRACT

Two field experiments were carried out during the two successive winter seasons of 1999/2000 and 2000/2001 at the experimental farm. Faculty of Agriculture, Alexandria University in Damanhour, El-Behira governorate. The objectives of this investigation was to study the main effects of Six N fertilizer levels (0, 18, 36, 54, 72 and 90 kg N fed^{-1}) and three different biofertilizer types Microbein (a mixture of *Azotobacter* , *Azospirillum* , *Pseudomonas* , *Rhizobium* and *Bacillus*), Rhizobacterin (a mixture of *Azotobacter* and *Azospirillum*) and Halex-2 (a mixture of *Azotobacter, Azospiillum* and *Kebsiella*) as well as their interaction on vegetative growth characters ,leaf chlorophyll contents and N content of storage leaves of onion (*Allium cepa L.*) cv. Giza 20. The obtained results indicated that application of mineral N, significantly increased plant length, plant fresh weight, leaves fresh weight plant^{-1}, leaves dry weight plant^{-1} and leaves dry matter percentage over the untreated plants, in both seasons. Meanwhile application of N fertilizer irrespective of the level used, did not affect number of leaves plant^{-1}. The highest two N rates 72 and 90 kg N fed^{-1} were remarkable and associated with the highest mean values for the most studied characters, but the differences between them were not found significant. Mean values of all the studied growth characters except leaves number, showed significant increments with the inoculated plants comparing with untreated ones. Moreover, Halex-2 application of the biofertilizer reflected the highest mean values for all the studied growth parameters, leaves chlorophyll content and storage leaves N content. Fertilization of onion plants with 72 or 90 kg N fed^{-1} combined with Halex-2 was the best interaction treatment for all the growth parameters.

INTRODUCTION

Onion (*Allium cepa* L.) has been grown since before recorded history. It is one of the most important vegetables due to high income and its great consumption popularity. It has enormous nutritional and medical values because of its contents of carbohydrates, proteins, vitamins, minerals and antioxidant substances (Paul and Southgate, 1987).

Nitrogen is an element required for plant growth. It is an fertilizers in a balance and rational way to keep high and stable yield in important component of proteins, enzymes and vitamins in plant and is a central part of the chlorophyll, the essential photosynthetic molecule. Application of high rates of N to the shallow-rooted onion crop is a common practice by onion growers to insure high yields and bulb quality (Randle, 2000). The excessive application of chemical fertilizers led to increasing production cost and diminishing soil fertility. The residual of chemical fertilizers has seriously affected the quality of agricultural products and people's health, caused environmental pollution; therefore a great interest has been generated to apply bioorganic and inorganic addition to establishment a good eco-environment.

Biofertilizers are living microorganisms involved in symbiotic and associative microbial activities with higher plants. They are used for increasing agricultural productivity and improving soil fertility. The use of biofertilizers have been recommended by several investigators to substitute partially chemical fertilizers (Sabr, 1993 and Gomma *et al.* 1999) through its positive influence on plant growth as illustrated by Nieto and Frankenberger (1990); Chauhan *et al.* (1996) and Sundaravelu and Muthukrishinan (1993). Hence, present investigation undertaken to examine the effect of different commercial biofertilizers on vegetative growth characters of onion plants (*Allium cepa* L.) with graded levels of nitrogen.

MATERIALS AND METHODS

Two field experiments were conducted at the experimental station farm, at El. Bostan region, Faculty of Agriculture Alexandria University in Damanhour, Behira Governorate during the two winter seasons of 1999/2000 and 2000/2001.

The physical and chemical analyses of the soil (Table 1) were carried out before planting according to the methods of Black (1965).

Table (1): Physical and chemical characteristics of the experimental site in 1999/2000 and 2000/2001 seasons.

Soil Properties			
Physical:			
Sand	84.24		(%)
Silt	11.00		(%)
Clay	4.76		(%)
Soil texture	Sandy		
Chemical:	1999	2000	
E.C.	2.16	2.34	(dsm^{-1})
PH	8.11	8.16	
Total N	0.22	0.30	gkg^{-1}
Total P	0.80	0.90	gkg^{-1}
Total K	0.90	0.11	gkg^{-1}
Organic matter	1.4	1.9	gkg^{-1}

The experimental layout was split plot in a randomized complete blocks design with four replicates contained 24 treatments, which were the combination between six mineral nitrogen fertilizers levels (0, 18, 36, 54, 72 and 90 kg N fed^{-1}.) arranged at random in the main plots and four biofertilizer treatments: uninoculated, microbein(a mixture of *Azotobacter* , *Azospirillum* , *Pseudomonas* , *Rhizobium* and *Bacillus*), Rhizobacterin (a mixture of *Azotobacter* and *Azospirillum*) and Halex-2 (a mixture of *Azotobacter* , *Azospillum* and *Klebsiella*) assigned at random in subplots. Onion transplants cv. Giza 20 (60 days old) were dipped into the biofertilizer prepared solution of a single biofertilizer at a rate of 400g $fed.^{-1}$(according to the Agricultural Ministry Lab. recommendations) just before transplanting whereas, uninoculated seedlings were soaked in distilled water.

Plots ($14m^2$) were fertilized with calcium super-phosphate (15.5% P_2O_5) at the rate of 300 kg fed^{-1} added as one dose during soil preparation. Potassium sulfate (48% K_2O) was added at the rate of 150 kg fed^{-1} . Nitrogen fertilizer levels as ammonium nitrate (33.3% N) were added at four equal doses 15, 35, 55 and 75 days after transplanting. Onion transplantation was carried out on the 9^{th} and 14^{th} of December in 1999/2000 and 2000/2001 respectively.

For measuring growth parameters, five plant samples were harvested (90 days after transplanting) from each plot and the obtained data were recorded for plant length, number of leaves plant $^{-1}$, leaves fresh weight plant $^{-1}$, plant fresh weight (Leaves and bulb), leaves dry matter percentage (a percentage of leaves dry weight / leaves fresh weight) and total chlorophyll content of leaves(measured by a digital chlorophyll meter SPAD-502).Total nitrogen was determined in storage leaves as outlined in FAO (1980).

Statistical analysis were carried out using C ostat s oftware p rogram (1985) and treatment means were compared at 0.05 level using the revised L.S.D test as illustrated by Snedecor and Cochran (1980).

RESULTS AND DISSCUSSION

Effect of mineral nitrogen

Data presented in Tables 2 and 3 clearly showed that the main effects of mineral N fertilizer rates on plant length, leaves fresh weight $plant^{-1}$, leaves dry matter percentage and plant fresh weight were significant, in both seasons.

Table (2): The main effects of nitrogen fertilizer rates and biofertilizer types on the growth characters of onion plants during the winter season of 1999/2000.

Treatments	Plant* length (cm)	No. leaves $plant^{-1}$	Plant fresh weight (g)	Leaves fresh weight plant-1(g)	Leaves dry matter (%)
N rate (kg fed^{-1})					
0	37.54D	7.15	113.05 D	38.82C	14.10 D
18	42.80 C	7.27	122.02 C	42.15B	15.40C
36	43.05 C	7.47	128.22 AB	42.50 B	15.97C
54	43.95 C	7.72	128.10 B	43.37 B	16.02BC
72	47.95 A	8.50	133.52 A	42.02 B	16.62AB
90	45.75 B	8.02	133.52 A	48.85A	16.87 A
Biofertilizer type					
Uninoculated	39.26 D	6.68	119.58 C	37.93 C	15.03C
Microbein	42.36 C	7.80	125.90 B	43.37 B	15.73B
Rhizobacterin	45.43 B	7.97	129.15 AB	46.17 A	16.18 AB
Halex-2	46.90 A	8.32	131.00 A	47.68 A	16.38A

* Values marked with the different alphabetical letter(s) within a particular comparable group of means, are statistically different using revised L.S.D. test at p=0.05 absence of the alphabetical letter(s) indicate a non-significant difference.

However, number of leaves $plant^{-1}$ was not significantly, affected. Application of N fertilizer up to 90 kg $fed.^{-1}$ significantly increased plant growth characters, compared with the control in both seasons. Moreover, the higher values were obtained from the treatments received either 72 or 90 kg N fed^{-1}. These favorable influences may be explained on the basis of the physiological fact that N is known as an essential element for vegetative growth and plays a major role in nucleic acids and protein synthesis, cell division and elongation and protoplasm formation (Marchner, 1986). Similar findings were supported by several researchers as El-Sayed *et al.* (1987), Koriem and Farag (1990), El-Gamili (1996) , Abd El-Maksoud and El-Swaff (2000) working on onio and Abd El-Fattah and Sorial (1998) working on lettuce. On the other hand, the application of various rates of N, in the present study, did not appear to affect number of leaves plant^{-1}. This result is in line with those of El-Oksh *et al.* (1993) and El-Gizawy *et al.* (1993) who reported that N application did not affect number of leaves of onion plants.

Table (3): The main effects of nitrogen fertilizer rates and biofertilizer types on the growth characters of onion plants during the winter season of 2000/2001.

Treatments	Plant length* (cm)	No. leaves plant^{-1}	Plant fresh weight (g)	Leaves fresh weight plant-1 (g)	Leaves dry matter (%)
N rate (kg fed^{-1})					
0	38.35 E	7.42	122.45 C	38.65 D	15.17 C
18	41.42 D	7.65	124.35 C	40.77 C	15.52 C
36	44.70 C	7.90	133.15 AB	42.42 C	16.50 AB
54	45.25 BC	8.72	130.45 B	46.27 B	16.27 B
72	47.47 AB	9.07	137.75 A	48.82 A	16.82 AB
90	47.75 A	9.27	135.90 A	49.07 A	16.97 A
Biofertilizer type					
Uninoculated	40.30 C	7.48	123.38 C	38.20 C	15.16 C
Microbein	44.30 B	8.40	129.08 B	44.05 B	16.13 B
Rhizobacterin	45.68 A	8.58	133.66 A	46.71A	16.55 B
Halex-2	46.35 A	8.92	136.55 A	46.38 A	17.00 A

*** Values marked with the different alphabetical letter(s) within a comparable group of means, are statistically different using revised L.S.D. test at p=0.05 absence of the alphabetical letter(s) indicate a non-significant difference.**

The effect of N fertilizer rates on leaf chlorophyll content was significant and the trend was approximately similar in both seasons (Table 6). The statistical comparison among the different N rates showed that, at 90 kg N fed^{-1}, leaf chlorophyll content, significantly, surpassed those of lower N rates. This can be attributed to the sufficient N uptake, enhanced onion plants to absorb more N and in turn to build more chlorophyll molecules, whereas N is considered as the backbone of chlorophyll structure, this results is confirmed by that recorded by El-Beheidi *et al.* (1996) and Tartoura and El-Saeid(2001) working on pea plants.

Effect of biofertilizers

Concerning the influence of different biofertilizer types on the various vegetable growth parameters of onion plants, the recorded results (Table 2 and 3) clarified that the inoculation of onion seedlings with any of the tested biofertilizers, significantly, stimulated plant length, leaves fresh weight, plant fresh weight and leaves dry matter percentage compared with the uninoculated treatments, in both seasons. In addition, Halex-2 exhibited the highest mean values for all the previously mentioned growth parameters followed by Rhizobacterin, whereas microbein produced the lowest values in both seasons. The enhancing effect of the biofertilizers application have been attributed to several mechanisms, including biological nitrogen fixation, dissolving immobilized P and producing plant growth promoting substances (Okon and Itzigsohn 1995 and Okan and Labandera-Gonzalez 1994)

Fallik *et al.* (1994) indicated that the non-symbiotic N2- fixing bacteria of genera *Azospirillium* produced adequate amounts of IAA and cytokinins which increased the number of lateral roots and root hairs causing absorption of sufficient nutrients and foster luxuriantly. Our findings agreed generally with those of Ali and Selim (1996), Barakat and Gabr (1998) and El -Zeiny *et al.* (2001) on tomato; Ghoneim and Abd El-Razik (1999) on potato; Shibob (2000) on common bean; Ishaq (2002) and Solieman *et al.* (2003) on pea; Musmade *et al.* (1987) and Martinez *et al.* (1994) on onion.

Leaf chlorophyll content was significantly higher with the inoculation of seedlings with each of the three different biofertilizer types than the uninoculated ones (Table 6) Furthermore, the biofertilizer Halex-2 was more effective in enhancing chlorophyll formation than the other two biofertilizers .

Mineral nitrogen and biofertilizers interaction

The interaction between N levels and biofertilizers did significantly affect all the studied growth parameters (Table 4 and 5) in both seasons.

Table (4): The interaction effects of nitrogen fertilizer rates and biofertilizer types on the growth characters of onion plants during the winter season of 1999/2000.

Biofertilizer type	N rate (kg fed^{-1}) *					
	0	18	36	54	72	90
Plant length (cm)						
Uninoculated	32.7 m	39.3 k	40.4 i-k	39.6 k	43.3 gh	40.3 jk
Microbein	36.2 l	42.2 hi	41.0 i-k	41.7 h-j	47.2 de	45.9 d-f
Rhizobacterin	39.8 k	44.2 fg	44.5 e-g	46.2 de	50.6 a	47.3 cd
Halex-2	41.1 i-k	45.5 d-f	46.3 de	48.3 bc	50.7 a	49.5 ab
No. Leaves plant^{-1}						
Uninoculated	6.4	6.2	6.4	7.0	7.0	7.1
Microbein	7.0	7.5	7.4	7.7	9.1	8.1
Rhizobacterin	7.4	7.6	8.0	7.9	8.6	8.3
Halex-2	7.8	7.8	8.1	8.3	9.3	8.6
Leaves fresh weight (g)						
Uninoculated	33.8 k	35.8 jk	37.3 ij	37.5 ij	40.1 g-i	43.1 d-g
Microbein	38.4 h-j	44.9 b-e	41.7 e-j	43.7 c-f	44.2 b-f	47.3 b
Rhizobacterin	40.2 g-l	41.0 f-h	46.5 bc	46.9 bc	54.3 a	51.1 a
Halex-2	42.9 d-g	46.9 bc	44.5 b-e	45.4 b-d	52.5 a	53.9 a
Plant fresh weight (g)						
Uninoculated	108.4 l	112.0 kl	122.6 g-l	120.2 h-j	126.0 f-h	128.3 d-g
Microbein	109.9 l	117.9 i-k	128.3 d-g	131.3 b-f	132.9 a-f	134.0 a-e
Rhizobacterin	120.3 h-j	129.0 c-g	127.0 e-h	128.2 d-g	136.3 a-c	134.8 a-d
Halex-2	113.2 j-l	129.2 c-g	135.0 a-d	132.7 a-f	138.9 a	137.0 ab
Leaves dry matter (%)						
Uninoculated	13.5 j	14.7 hi	15.3 f-h	15.0 gh	15.7 e-g	16.0 c-f
Microbein	13.7 j	14.7 hi	16.0 c-f	16.1 c-f	17.1 ab	16.8 a-c
Rhizobacterin	15.1 gh	16.1 c-f	15.8 d-g	16.4 b-e	16.4 b-e	17.3 a
Halex-2	14.1 ij	16.1 c-f	16.8 a-c	16.6 a-d	17.3 a	17.4 a

*** Values marked with the different alphabetical letter(s), within a particular comparable group of means, are statically different using revised L.S.D. test at P=0.05. Absence of the alphabetical letter(s) indicate a non-significant difference.**

Table (5): The interaction effects of nitrogen fertilizer rates and biofertilizer types on the growth characters of onion plants during the winter season of 2000/2001.

Biofertilizer type	N rate (kg fed⁻¹)*					
	0	18	36	54	72	90
Plant length (cm)						
Uninoculated	33.7 k	36.5 j	40.4 i	42.4 g-l	43.9 e-h	44.8 d-g
Microbein	37.7 j	40.6 l	45.5 c-f	45.6 c-f	48.9 a	47.9 a-c
Rhizobacterin	41.9 hi	43.0 f-l	47.1 a-d	44.6 d-g	48.6 a	48.9 a
Halex-2	40.5 i	45.6 c-f	45.8 b-e	48.4 ab	48.5 a	49.3 a
No. leaves plant⁻¹						
Uninoculated	6.8	6.9	7.1	7.7	7.8	8.6
Microbein	7.5	7.6	7.7	9.0	9.1	9.5
Rhizobacterin	7.5	7.9	8.8	8.6	9.2	9.4
Halex-2	7.9	8.2	8.0	9.6	10.2	9.6
Leaves fresh weight (g)						
Uninoculated	33.4 m	34.1 m	36.5 lm	39.5 hl	41.9 i-l	43.8hi
Microbein	38.3 l	39.3 kl	43.0 h-j	46.1 f-h	49.6 b-e	48.0 d-f
Rhizobacterin	39.8 j-l	42.2 i-k	44.3 g-l	51.4 a-c	51.6 ab	51.0 a-d
Halex-2	43.1 h-i	47.5 e-g	45.9 f-h	48.1 c-f	52.2 ab	53.5 a
Plant fresh weight (g)						
Uninoculated	114.5 k	115.4 jk	125.9 f-h	122.9 hi	131.4 d-f	130.2 ef
Microbein	121.5 h-k	119.5 i-k	134.7 b-e	125.8 f-h	137.7 bc	135.3 b
Rhizobacterin	124.0 g-l	132.4 c-e	135.5 b-d	135.5 b-d	136.9 b-d	137.7 bc
Halex-2	129.8 e-g	130.1 e-g	136.5 b-d	137.6 bc	145.0 a	140.4 ab
Leaves dry matter (%)						
Uninoculated	14.3 j	14.4 ij	15.4 gh	15.4 gh	15.2 i	16.3 d-f
Microbein	15.2 j	14.9 h-j	16.9 b-e	15.7 f-h	17.2 a-c	16.9 b-e
Rhizobacterin	15.1 h-j	16.5 c-f	16.6 c-e	16.9 b-e	17.1 a-d	17.1 a-d
Halex-2	16.1 e-g	16.3 d-f	17.1 a-d	17.1 a-d	17.9 a	17.5 ab

* Values marked with the different alphabetical letter(s), within a particular comparable group of means, are statically different using revised L.S.D. test at P=0.05. Absence of the alphabetical letter(s) indicate a non-significant difference.

Table (6): The main effects of nitrogen fertilizer rates and biofertilizer types on total chlorophyll content of onion plants during the winter seasons of 1999/2000 and 2000/2000.

Treatments	Total chlorophyll content* (SPAD)**	
	1999/2000	2000/2001
N rate (kg fed⁻¹)		
0	60.02 C	60.92 C
18	60.52 C	61.47 C
36	60.22 C	61.30 C
54	62.07 B	62.27 BC
72	63.32 B	63.77 AB
90	65.40 A	64.60 A
Biofertilizer types		
Uninoculated	59.33 C	58.52 C
Microbein	61.40 B	62.25 B
Rhizobacterin	62.28 B	63.75 AB
Halex -2	64.78 A	64.74 A

* Values marked with the different alphabetical letter(s), within a particular comparable group of means, are statistically different using revised L.S.D test at p= 0.05.
** SPAD " Specialty Products Agricultural Division " = 10 mg chlorophyll g-1 fresh weight.

On the other hand the average number of leaves per plant was not significantly affected by such an interaction in both seasons. Moreover, inoculation onion plants with the biofertilizer Halex-2 or Rhizobacterin along with N application of 72 or 90 kg N fed-1 was pronounced and exhibited an enhancement in growth characters. These results are confirmed with those of Ghoneim and Abd El-Razik (1999) on potato, Abd El-Fattah and Sorial (2000) on summer squash and Gabr *et al.* (2001) on sweet pepper.

The interaction effects between N fertilizer rates and biofertilizer types on the total chlorophyll content of leaves in 1999/2000 and 2000/2001 (Table 7) revealed that, at higher N rates, 72 and 90 kg N fed^{-1} the inoculation of onion seedlings attained the highest Chlorophyll content of leaves. These results are in line with those of Dawa *et al.* (2000), El-Zeiny *et al.* (2001) working on tomato and Gabr *et al.* (2001) working on sweet pepper.

Table (7): The interaction effects of nitrogen fertilizer rates and biofertilizer types on total chlorophyll content (SPAD) of onion plants during the winter seasons of 1999/2000 and 2000/2001.

Biofertilizer types	N rate (kg fed^{-1})					
	0	18	36	54	72	90
1999/2000						
Uninoculated	58.90*jk	58.70 j-l	57.00 kl	58.60 j-l	60.60 g-j	62.20 e-h
Microbein	59.60 ij	61.60 f-l	56.30 l	61.10 f-j	63.40 c-f	65.90 a-c
Rhizobacterin	59.80 h-j	58.60 j-l	63.10 d-g	63.00 e-g	63.10 d-g	66.10 ab
Halex-2	61.80 f-i	63.20 d-f	64.50 b-e	65.60 a-d	66.20 ab	67.40 a
2000/2001						
Uninoculated	57.40 kl	59.30 i-l	56.80 l	58.50 j-l	58.60 j-l	60.50 h-k
Microbein	62.30 e-i	61.80 f-l	57.20 l	63.90 b-f	66.4. ab	63.70 c-g
Rhizobacterin	60.70 gj	63.60 b-f	65.30 a-e	62.90 d-h	62.80 d-h	66.90 ab
Halex-2	63.30 c-h	60.90 f-j	65.90 a-d	63.80 b-g	67.30 a	67.80 a

* Values marked with the different alphabetical letter(s), within a particular comparable group of means, are statistically different using revised L.S.D test at p = 0.05.

The correlation coefficients between Leaves chlorophyll content and plant fresh weight of onion in Table (8) indicate that statistical significance does exist only in the presence of biofertilizer Halex-2 and they were 0.807 and 0.856 in 1999/2000 and 2000/2001 seasons respectively. Therefore, It is indicated that halex-2 was the most effective biofertilizer in increasing plant fresh weight.

Table (8) : Correlation between leaves chlorophyll content and plant fresh weight of onion as affected by nitrogen rates and biofertilizers inoculation.

Biofertilizer types	Correlation Coefficient (R)	
	1999 / 2000	2000 / 2001
Uninoculated	0.496	0.283
Microbein	0.402	0.124
Rhizobacterin	0.612	0.729
Halex-2	0.867*	0.856*

*Significant at P< 0.05 level

Nitrogen content of storage leaves

The effect of N fertilization rates on storage leaves N content was significant in both seasons (Table 9). Tissue N concentration increased significantly with increasing N level up to 72 kg N $fed.^{-1}$ in the first season and 54 kg N $fed.^{-1}$ in the second season. Obtained results and in harmony with those obtained by Oukal (1999) and Patel *et al.* (1992) who reported that, the addition of N to the soil increased its level in the soil solution and consequently increased its uptake by the plants.

Nitrogen content data in onion tissue as affected by different commercial biofertilizer treatments are presented in Table (9). All biofertilizer treatments resulted in significant increase in total nitrogen concentration in onion's storage leaves as compared to the uninoculated treatment in both seasons. In this respect Halex-2 was the most pronounced biofertilizer and associated with the highest mean value for nitrogen concentration in both seasons, this superior effect may be due to Halex-2 is the only biofertilizer has three different genera of non – symbiotic nitrogen fixing bacteria. Similar results were reported by Sanaratne and Ratnsinghe (1995) and James (2000).

Table (9): The main effect of nitrogen fertilizer rate and biofertilizer types on total nitrogen content of storage leaves during the winter seasons of 1999/2000 and 2000/2001.

Treatment	Total N content of storage leaves (%)	
	1999/2000	2000/2001
N rate (kg fed^{-1})		
0	2.02 C*	1.80 C
18	2.15 BC	2.27 B
36	2.17 BC	2.31 B
54	2.59 ABC	2.87 A
72	2.99 A	3.03 A
90	2.86 AB	3.02 A
Biofertilizer type		
Uninoculated	2.19 B	2.21 D
Microbein	2.32 B	2.45 C
Rhizobacterin	2.56 AB	2.59 B
Halex-2	2.79 A	2.96 A

*** Values marked with the different alphabetical letter(s), within particular comparable group of means, are statistically different using revised L.S.D. test at P=0.05.**

Concerning the interaction effects on nitrogen content between N rates and biofertilizer types data in Table (10) reflected significant effects on nitrogen content in both seasons. The application of mineral nitrogen at the rate of 72 kg N $fed.^{-1}$ combined with the biofertilizer Halex-2 exhibited the highest nitrogen content in the second season whereas in the first season both of Halex-2 and Rhizobacterin combined with 72 kg N $fed.^{-1}$ reflected the higher mean values. The increase in nitrogen content was expected since the biofertilizer application was nitrogen-fixing bacteria which enhance nitrogen uptake as reported, by Pandy and Kumar (1989) and Abd El-Azeem (1998).

Table (10): The interaction effects of nitrogen fertilizer rates and biofertilizer types on nitrogen content of storage leaves during 1999/2000 and 2000/2001 seasons.

	N rate (kg fed^{-1})					
	0	18	36	54	72	90
1999/2000 N (%)						
Uninoculated	1.47n	1.93 l	1.66 m	1.90 l	2.12 jk	1.96 kl
Microbein	2.22 h-j	2.28 h-j	2.17 ij	2.30 hi	2.48 e-g	2.66 b-d
Rhizobacterin	1.80 lm	2.29 h-j	2.11 jk	2.31 g-i	2.85 a	2.62 c-e
Halex-2	1.82 lm	2.40 f-h	2.80 ab	2.52 d-f	2.7 a-c	2.80 ab
2000/2001 N (%)						
Uninoculated	1.47 m	2.37 f-h	2.29 gh	2.48 e-g	2.24 hi	2.39 f-h
Microbein	1.95 kl	2.57 ef	2.38 f-h	2.52 e-g	2.99 c	2.32 gh
Rhizobacterin	1.78n l	2.19 h-j	2.24 hi	3.57 b	2.71 de	3.03 c
Halex-2	2.02 l-k	1.96 j-l	2.33 f-h	2.91 cd	4.24 a	4.34 a

* Values marked with the different alphabetical letter(s), within a particular comparable group of means, are statically different using revised L.S.D. test at P=0.05.

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تأثير التسميد النيتروجيني والحيوى على النمو الخضرى لنباتات البصل

محمد أمين بركات[1] – حسن احمد الخطيب[2] – سعيد محمد جبر[2] – ابتهال على بديوى[3]

[1]قسم البساتين – كلية الزراعة – الفيوم – جامعة القاهرة

[2]قسم البساتين – كلية الزراعة – دمنهور – جامعة الإسكندرية

[3]ادارة الخبراء– وزارة العدل– دمنهور– محافظة البحيرة

أجريت تجربتان حقليتان فى الموسمين الشتويين لعامى ١٩٩٩/٢٠٠٠ و ٢٠٠٠/٢٠٠١ بالمزرعة التجريبية لكلية الزراعة – جامعة الإسكندرية – بدمنهور – محافظة البحيرة بهدف دراسة تأثير إضافة ستة مستويات متزايدة من التسميد النيتروجينى المعدنى (صفر، ١٨ ، ٣٦ ، ٥٤ ، ٧٢ ، ٩٠ كيلو جرلم نيتروجين/فدان) مع ثلاثة أنواع مختلفة من الأسمدة الحيوي (الدراسة تأثير ثلاثة أنواع مختلفة من السماد الحيوى ;ميكروبين(*Azotobacter* و *Azospirillum* و *Pseudomonas* و *Rhizobium* و *Bacillus*) رايزوباكتيرين (*Azotobacter* و*Azospirillums*)هاليكس–٢(*Aztobacter* و*Azospirillum* و*Klebsiella*) والتداخلات بينهم على صفات النمو الخضرى ومحتوى الأوراق من الكلوروفيل لنبات البصل صنف جيزه ٢٠ ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى :

١-أدى إضافة السماد النيتروجينى المعدنى إلى زيادة معنوية فى طول النبات والوزن الطازج للأوراق والوزن الطازج للنبات والنسبة المئوية للمادة الجافة للأوراق ومحتواها من الكلوروفيل مقارنة بالنباتات الغير معاملة فى كلا الموسمين بينما لم يظهر أى تأثير معنوى على عدد الأوراق لكل نبات.

٢-أدت إضافة السماد النيتروجينى بمعدل72 ،90 كجم نيتروجين/فدان إلى زيادة معنوية فى كل الصفات موضع الدراسة عدا عدد الأوراق مقارنة بالمعدلات الأخرى ولم تظهر نتائج الدراسة أى فرق معنوى بين هذين المعدلين.

٣-أظهرت نتائج تلقيح شتلات البصل باى من الأسمدة الحيوية المستخدمة تفوقا على الشتلات غير الملقحة فى كل صفات النمو الخضرى المدروسة وكذلك محتوى الأوراق من الكلوروفيل وايضا محتوى الاوراق المخزنة (الابصال) من النيتروجين بينما لم يظهر عدد الأوراق أى إستجابة معنوية. ولقد أعطى التلقيح بإستخدام هالكس –٢ أفضل النتائج فى صفات النمو الخضرى ومحتوى الأوراق من الكلوروفيل وايضا محتوى الاوراق المخزنة (الابصال) من النيتروجين.

٤-أظهرت نتائج موسمى الدراسة أن هناك تأثيرات معنوية للتداخل بين التسميد النيتروجينى المعدنى والحيوى على كل صفات النمو الخضرى المدروسة وكذلك محتوى الأوراق من الكلوروفيل وايضا محتوى الاوراق المخزنة (الابصال) من النيتروجين بإستثناء عدد الأوراق لكل نبات. ولقد تحققت أفضل النتائج عند تلقيح شتلات البصل بالسماد الحيوى هالكس–٢ وتسميد النباتات بمعدل ٧٢ أو ٩٠كجم نيتروجين/فدان .

٥-لذلك يوصى باستخدام هاليكس –٢ مع تسميد نيتروجينى بمعدل ٧٢ كجم نيتروجين /فدان.

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STATISTICAL MODELS FOR PREDICTING YIELD RESPONSE OF ONION (*Allium Cepa* L.) TO APPLIED NITROGEN AND BIOFERTILIZERS

Elkhatib,H.A[1]; S.M.Gabr[1]; M.A. Barakat[2] and E.A.Bedawy[3]
[1]Horticulture Dept., Faculty of Agric., Damanhour, Alex. University
[2]Horticulture Dept., Faculty of Agric., Elfayom, Cairo University
[3]Experts Dept., Ministry of Justice, Damanhour, El-Behira

ABSTRACT

Two field experiments were conducted during the two successive winter seasons of 1999/2000 and 2000/2001 to evaluated the effect of three commercial biofertilizers: microbein(a mixture of *Azotobacter* , *Azospirillum* , *Pseudomonas* , *Rhizobium* and *Bacillus*), Rhizobacterin (a mixture of *Azotobacter* and *Azospirillum*) and Halex-2 (a mixture of *Azotobacter*, *Azospiillum* and *Kebsiella*) with different nitrogen fertilizer levels (0,18,36,54,72 and 90 kg N fed.$^{-1}$) on bulbs yield of onion (*Allium cepa* L.) cv. giza 20 and its component (total bulb yield ton fed^{-1}, marketable bulb weight (g), Average bulb weight (g), and average bulb diameter (cm).

Generally, addition of 72 kg N fed.$^{-1}$ combined with Halex-2 biofertilizer was sufficient and adequate to produce maximum and economic yield in both seasons.

Four polynomial quadratic equations were established to express the response of onion bulbs yield to N fertilization and biofertilizers inoculation. The experimental yield values and the corresponding calculated values were not significantly different as tested by the standard error of estimates SE and high values of correlation coefficient (R). $N_{opt.}$ and corresponding $Y_{opt.}$ were calculated for both years and the data revealed that the N fertilization application was more profitable when applied to onion seedlings with the biofertilizer Halex-2 as indicated by highest values of net returns compared with the other treatment combinations.

INTRODUCTION

Onion (*Allium cepa. L.*) is one of the oldest vegetable crops. It has been cultivated for thousands of years for its religious significance, medical properties and for its pungency and characteristic flavor (Hanly and Fanwick, 1985). It is considered one of the most important vegetable crops in Egypt for local consumption and export.

Nitrogen is an important element, which affect yield and quality of onion bulbs. Nitrogen nutrition can also influence onion bulb development and flavor, (Brewster and Butler, 1989; El-Oksh *et al.* 1993; Khalil et al. 1988 and El-Gamili and Abd El-Hadi 1996) and maximize marketable yields and percentage of large-sized onion bulbs (Vachhani and Patel, 1996; El-Gamili, 1996 and El-Gamili *et al.* 2000).

Recently, mineral fertilization became a target of criticism because of heavy use in the developing countries, where, it was suspected of having an adverse impact on the environment through nitrate leaching, and heavy metal uptakes by plants. This has led to a call for rational use of chemical fertilizers combined with organic and bio-sources to increase productivity and protect environment.

Biofertilizers are natural mini fertilizer factories that are economical and safer source of plant nutrition and they can be used as alternatives for chemical fertilizers. Remarkable effects of biofertilizers on yield of some crops have been reported by several investigators (Mishustin and Shilinkova, 1996; Iman and Badawy, 1978; Azad and Aslam, 1984 and Ashour *et al.*, 1997) working on Potato, and Barakat , Gabr, 1998 on Tomato and Elkhatib 2003 on peas.

The objectives of this study were:(1) to evaluate the effect of N fertilization with different levels and inoculation with various biofertilizer types on the bulbs yield and its components in order to explore the possibility of reducing amount of artificial N fertilizer by adding biofertilizers for the purpose of reducing the environmental pollution and production cost and (2) to quantify onion yield response to nitrogen fertilization with different types of biofertilizers using polynomial quadratic equations.

MATERIALS AND METHODS

Two field experiments were carried out at the experimental station farm, El-Bostan region, faculty of agriculture Alexandria university in Damanhour, Behira Governorate in the two winter seasons of 1999/2000 and 2000/2001. The physical and chemical characteristics of the soil (Table 1) were determined according to the methods reported by Black (1965). The experimental layout was split plot in a randomized complete blocks design with four replicates. Six nitrogen rates (0,18,36,54,72 and 90 kg N Fed^{-1}) were occupied the main plots; whereas 4 biofertilizer treatments: microbein(a mixture of *Azotobacter* , *Azospirillum* , *Pseudomonas* , *Rhizobum* and *Bacillus*), Rhizobacterin (a mixture of *Azotobacter* and *Azospirillum*) and Halex-2 (a mixture of *Azotobacter*, *Azospiillium* and *Kebsiella*) with different nitrogen fertilizer levels were assigned at random in the sub-plots. Each experimental unit contained 5 ridges, 4m long and 70 cm wide. Calcium super-phosphate (15.5% P_2O_5) at a rate of 300 kg fed^{-1} was broadcasted during soil preparation. Potassium sulfate (48% k_2O) was added at a rate of 150 kg $fed.^{-1}$ at three equal parts 35, 55 and 75 days after transplanting.

Table (1): Physical and chemical characteristics of the experimental site in 1999/2000 and 2000/2001 seasons.

Soil Properties			
Physical:			
Sand	84.24		(%)
Silt	11.00		(%)
Clay	4.76		(%)
Soil texture	Sandy		
Chemical:	1999	2000	
E.C.	2.16	2.34	(dsm^{-1})
PH	8.11	8.16	
Total N	0.22	0.30	gkg^{-1}
Total P	0.80	0.90	gkg^{-1}
Total K	0.90	0.11	gkg^{-1}
Organic matter	1.4	1.9	gkg^{-1}

Nitrogen fertilizer levels as ammonium nitrate (33.5% N) were side banded at four equal doses15, 35, 55 and 75 days after transplanting. Onion transplants cv. Giza 20 (60 days old) were inoculated with the aqueous solution of a single biofertilizer at a rate of 400g fed.$^{-1}$(according to the Agricultural Ministry Lab. recommendations) just before transplanting whereas, uninoculated seedlings were soaked in distilled water. Uniform onion transplants were transplanted 10 cm a part on both sides of the ridges in the 9th and 14th of December of 1999 and 2000 respectively.

At harvesting time (170 days after transplanting) plants were harvested and cured for 10 days under traditional field conditions, then data were recorded for total yield (ton fed^{-1}), marketable bulb yield (bulb diameter more than 3.5 cm) ton fed^{-1}, Average bulb weight (g) and average bulb diameter (cm). All obtained data were statistically analyzed using Costat software program (1985) and the revised L.S.D. test was used to compare the differences among treatment means as illustrated by Snedecor and Cochran (1980).

RESULTS AND DISSCUSSION

Total bulb yield and its components:

Total bulb yield, marketable yield and average bulb weight reflected significant differences among the different nitrogen levels used in both seasons (Tables 2 and 3). Fertilizing onion plants significantly increased bulb yield and its components in comparison with the unfertilized treatment. In addition, increasing nitrogen levels caused a significant increase in bulbs yield and its component up to 72 kg N fed^{-1}. However the responses of increasing nitrogen level up to 90 kg N fed appeared to be insufficient to express a significant effect in both seasons. At 72 kg N fed^{-1} the increments in total bulb yield, marketable yield, average bulb yield and bulb diameter over the control were 44.9, 41.4, 27.5 and 59.5% in 1999/2000, whereas the corresponding values in 2000/2001were 35.9, 44.0, 18.6 and 45.9% respectively. These increments may be related to the role of N in enhancing vegetative growth, which lead to produce more photosynthetic material required for bulb production. These results are in agreement with those of El-Gamili et. al. (2000); and Abd El-Maksoud and Swaff 2000 and Batal *et al.* 1994.

Regarding the effects of biofertilizer on bulbs yield and its components, results in (Table 2) indicated high significant increments in total yield, marketable yield, average bulb weight and bulb diameter as a result of inoculation of onion plants with the tested biofertilizers in both seasons. Moreover, Halex-2 gave significantly the highest values for marketable bulbs yield in both seasons (Table 2) whereas; there were no significant differences between Halex-2 and Rhizobacterin on total yield and Avg. bulb diameter in both seasons. The beneficial effect of biofertilizers was due to improving N nutrition (Lazarovit and Nowak 1997), producing phytohormones which responsible for root hair branching and an eventual increase in nutrient uptake, (Noel *et al.*, 1996 and Jagnow *et al.* 1991) and/or biocontrol of plant disease through production of antibiotics, antibacterial and antifungal compounds (Baker, 1987; Pandy and Kumar, 1989 and Ottow *et al.* 1982). These results agreed to a great extent with those reported by Iman and Badawy (1978); Azad and Islam (1984); Barakat and Gabr (1998) and Gabr *et al.* (2001).

Table (2): The main effect of nitrogen fertilizer rate and biofertilizer types on total bulbs yield of onion plants and its component during the winter seasons of 1999/2000 and 2000/2001.

Treatments	Total bulb yield (ton fed^{-1})		Marketable bulb yield (ton fed^{-1})		Average bulb weight (g)		Average bulb diameter (cm)	
	1999	2000	1999	2000	1999	2000	1999	2000
N rate (kg fed^{-1})								
0	5.35 D*	5.40 D*	4.47 D	4.32 D	63.55 E	69.42 C	4.40 D*	4.90 D
18	6.37 C	6.52 C	4.75 C	5.02 C	66.90 D	71.10 BC	5.32 C	5.40 C
36	6.97 B	6.85 B	5.25 B	5.30 BC	71.02 C	73.27 B	5.70 C	5.75 BC
54	6.90 B	6.85 B	5.45 B	5.42 B	74.82 B	80.95 A	6.30 B	6.02 B
72	7.75 A	7.95 A	6.32 A	6.22 A	81.02 A	82.32 A	7.02 A	7.02 A
90	7.50 A	7.65 A	6.45 A	6.30 A	81.00 A	82.35 A	7.22 A	7.15 A
Biofertilizer type								
Unincculated	6.28 C	6.42 B	4.88 C	4.93 D	68.35 D	70.38 B	5.30 C	5.37 C
Microbein	6.73 B	6.58 B	5.45 B	5.35 C	71.63 C	78.01A	6.05 B	6.02 B
Rhizobacterin	6.98 A	7.05 A	5.60 B	5.56 B	74.88 B	78.08 A	6.13 A	6.32 A
Halex-2	7.15 A	7.10 A	5.87 A	5.86 A	77.60 A	79.72 A	6.50 A	6.47 A

*** Values marked with the different alphabetical letter(s), within particular comparable group of means, are statistically different using revised L.S.D. test at P=0.05.**

The effects of different interactions among the various levels of the nitrogen and different biofertilizers type on yielding ability of onion plants in two seasons are shown in (Tables 3 and 4). The results revealed that the highest mean values for total and marketable bulbs yield, average bulb weight and bulb diameter in the two seasons were obtained from the plants that were previously inoculated with the biofertilizer Halex-2 and given either 72 or 90 kg N fed^{-1}. Therefore the treatment combination of Halex-2 plus 72 kg N fed^{-1} appears to be sufficient and adequate to produce maximum and economic bulb yield. These results might be explained on the basis that the interactive effects of the two studied factors were additive. A large number of reports emphasized the beneficial effects of the interaction between mineral N fertilizer and inoculation with biofertilizer on productivity of different vegetable crops as Ashour *et al.* (1997), Barakat and Gabr (1998), Abd El-Mouty (2000) and Elkhatib (2003).

Table (3): The interaction effects of nitrogen fertilizer rates and biofertilizer types on bulbs yield of onion plants and its components during the winter season of 1999/2000.

Biofertilizer type	N rate (kg^{-1})					
	0	18	36	54	72	90
Total bulb yield (ton fed^{-1})						
Uninoculated	5.00k*	5.90g-k	6.10f-j	6.40a-e	7.30a-e	7.00b-f
Microbein	5.20jk	6.40e-i	6.50d-l	6.90b-g	8.00a	7.40a-e
Rhizobacterin	5.70h-k	6.50d-i	7.10a-f	7.10a-f	7.80ab	7.70a-c
Halex-2	5.50l-k	6.70c-h	7.40a-e	7.50a-d	7.90ab	7.90ab
Marketable bulb yield (ton fed^{-1})						
Uninoculated	4.40ij	3.90k	4.70hi	4.30j	5.80ef	6.20b-d
Microbein	4.50ij	4.70hi	5.00h	5.70fg	6.40a-c	6.40a-c
Rhizobacterin	4.50ij	5.00h	5.40g	5.70fg	6.50ab	6.50ab
Halex-2	4.50ij	5.40g	5.90d-f	6.10c-e	6.60a	6.70a
Average bulb weight (g)						
Uninoculated	55.90l	60.70k	67.50ij	72.00e-h	77.10d	76.90d
Microbein	61.00k	65.20j	69.70f-l	75.10de	77.30d	81.50bc
Rhizobacterin	67.90ij	68.20h-j	72.20e-g	75.50de	84.50a-c	81.00c
Halex-2	69.40g-i	73.50d-f	74.70de	76.70d	85.20ab	85.50a
Average bulb diameter (cm)						
Uninoculated	3.60l*	4.70jk	4.50jk	5.40gh	6.60cd	7.00a-c
Microbein	4.50jk	4.90ij	6.10ef	6.50de	7.10ab	7.20ab
Rhizobacterin	4.30k	5.60gh	5.80fg	6.50de	7.30a	7.30a
Halex-2	5.20hi	6.10ef	6.40de	6.80b-d	7.10ab	7.40a

* Values marked with the same alphabetical letter(s), within a particular comparable group of means, are statistically different using revised L.S.D. test at P=0.05.

Table (4): The interaction effects of nitrogen fertilizer rates and biofertilizer types on bulbs yield of onion plants and its components during the winter season of 2000/2001.

Biofertilizer type	N rate (kg^{-1})					
	0	18	36	54	72	90
Total bulb yield (ton fed^{-1})						
Uninoculated	4.80k*	6.50h-j	6.20j	6.40ij	7.20d-f	7.40b-e
Microbein	4.80k	6.50h-j	6.70g-i	6.60h-j	7.30c-f	7.60a-d
Rhizobacterin	6.00f-h	6.50h-j	7.30c-f	7.30c-f	7.50a-e	7.70a-c
Halex-2	6.00f-h	6.60h-j	7.20d-f	7.10e-g	7.80ab	7.90a
Marketable bulb yield (ton fed^{-1})						
Uninoculated	3.90j	4.70hi	4.30ij	4.80gh	6.00cd	5.90cd
Microbein	4.00j	5.10f-h	5.40ef	5.20fg	6.10b-d	6.30a-c
Rhizobacterin	4.00j	5.10f-h	5.70de	6.00cd	6.30a-c	6.30a-c
Halex-2	5.40ef	5.20fg	5.80de	5.70de	6.50ab	6.60a
Average bulb weight (g)						
Uninoculated	63.80l	64.40l	66.90kl	71.40h-j	77.10d-f	78.70c-e
Microbein	69.70jk	74.70f-h	74.20f-i	84.90ab	83.90ab	81.20b-d
Rhizobacterin	70.40h-j	72.30g-j	76.20e-g	83.30ab	81.60bc	84.70ab
Halex-2	73.80f-j	73.00f-j	75.80e-g	84.20ab	86.70a	84.80ab
Average bulb diameter (cm)						
Uninoculated	3.90n	4.80m	5.00lm	5.10k-m	6.60e-g	6.80d-f
Microbein	5.30j-l	5.30j-l	5.30j-l	5.90hi	6.90c-e	7.40ab
Rhizobacterin	5.50ik	5.80l	6.30gh	6.30gh	6.90c-e	7.10b-d
Halex-2	4.90lm	5.70ij	6.40fg	6.80d-f	7.70a	7.30a-c

* Values marked with the same alphabetical letter(s), within a particular comparable group of means, are statically different using revised L.S.D. test at P=0.05.

Polynomial Quadratic Models:

Onion bulbs yield responded positively to N fertilizer application rate and different biofertilizer types. The response to nitrogen increments was expressed by polynomial quadratic equation:

$$Y_i = B_o + B_i x_i + B_{ii} X_i^2 \qquad (1)$$

Where Y_i is the predicted yield corresponding to nutrient rate x_i.
B_o is the intercept, represents the yield without N fertilizer application, B_i and B_{ii} are the linear and quadratic coefficients respectively.
Four equations were established using the least squares methods described in Snedecor and Cochran (1980), to express the response of onion bulbs yield to nitrogen fertilizer at different biofertilizer types for each season. (Table 5 and Figs 1& 2).

Table (5): The polynomial quadratic equations expressing onion bulbs yield as affected by N fertilization and different biofertilizer types in 1999/2000 and 2000/2001 seasons.

Treatment	The polynomial Quadratic Equations		Determination Coefficient R^2
	Season 1999 / 2000		
Uninoculated	$Y_1 = -0.065x^2+0.70X+5.06$	(2)	0.92
Microbein	$Y_2 = -0.097x^2+0.91X+5.28$	(3)	0.88
Rhizobacterin	$Y_3 = -0.065x^2+0.76X+5.75$	(4)	0.96
Halex-2	$Y_4 = -0.130x^2+1.09X+5.64$	(5)	0.97
	Season 2000 / 2001		
Uninoculated	$Y_1 = -0.065x^2+0.715X+5.14$	(6)	0.81
Microbein	$Y_2 = -0.097x^2+0.913X+5.12$	(7)	0.86
Rhizobacterin	$Y_3 = -0.065x^2+0.676X+6.0$	(8)	0.96
Halex-2	$Y_4 = -0.032x^2+0.559X+6.05$	(9)	0.95

Onion bulbs yield was quadratically related to N rate in the two seasons studied. The experimental yield values and the corresponding calculated values from equations 2-9 were not significantly different as tested by the standard error of estimates SE, (Table 6) also both of the experimental and predicted yield have shown highly significant values of correlation coefficients (R) (Table 6).

The Economical Optimum Rate of N Fertilizer Application ($N_{opt.}$):

The optimum rates of N fertilizer applied ($N_{opt.}$) at each biofertilizer type (Table 7) was calculated by differentiating "Y" in eqs. 2 - 9 with regard to "x" (dy / dx) and equating with the ratio of price of fertilizer unit to price of crop unit (Capurro and Voss 1981).
The local price of unit N fertilizer (18 kg / fed) was 45 Egyptian pound (EP) and the local price of 1 ton of onion bulbs yield was 500 EP. The optimum N application rates ($N_{opt.}$) were 4.7, 4.2, 5.2, and 3.8 units of N fed^{-1} from the eqs. 2 - 5 (1999) and 4.8, 4.2, 4.5 and 7.3 unit of N $fed._{1}$from the polynomial eqs. 6-9 (2000) for uninoculated, Microbein, Rhizobacterin and Halex-2 respectively.

Fig (1): Total bulbs yield response curve of onion cultivar (giza 20) as a function of nitrogen application rate and different biofertilizer types during the season of 1999 / 2000

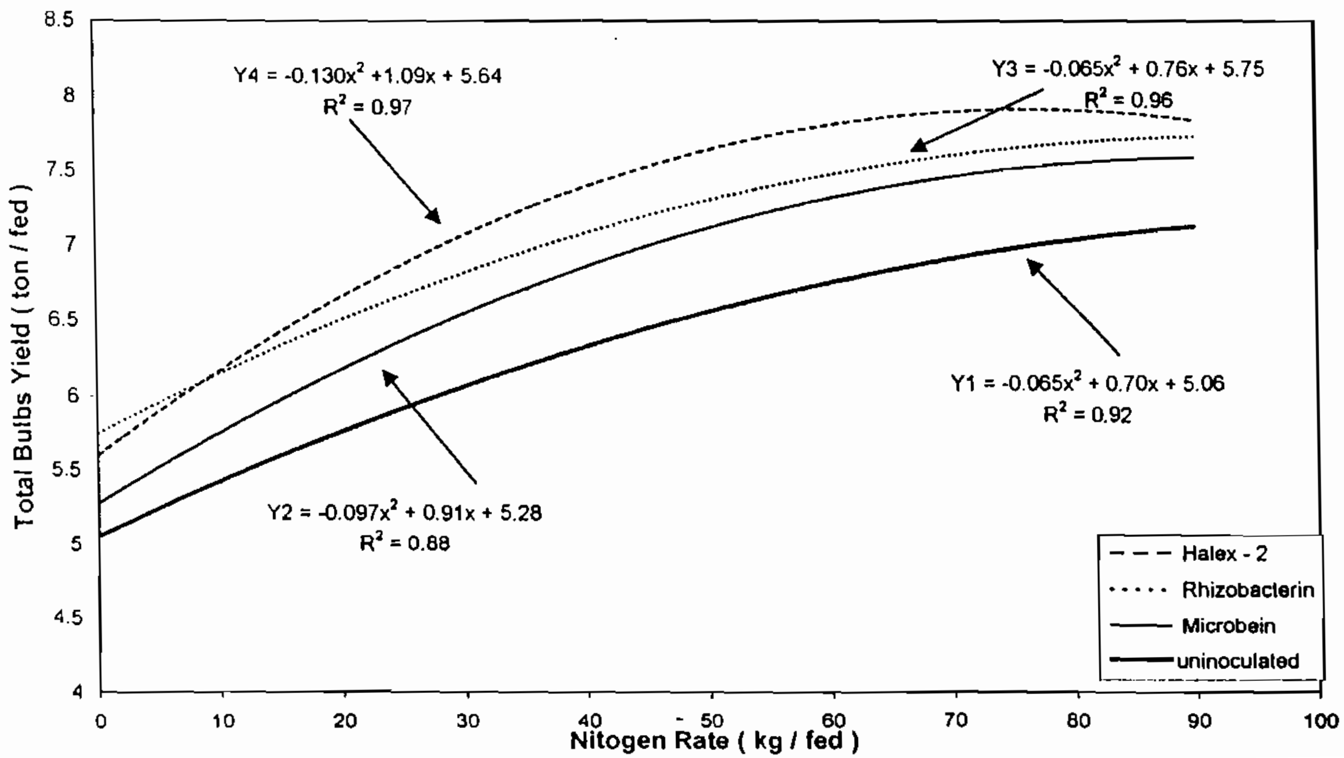

Fig (2): Total bulbs yield response curve of onion cultivar (giza 20) as a function of nitrogen application rate and different biofertilizer types during the season of 2000/ 2001

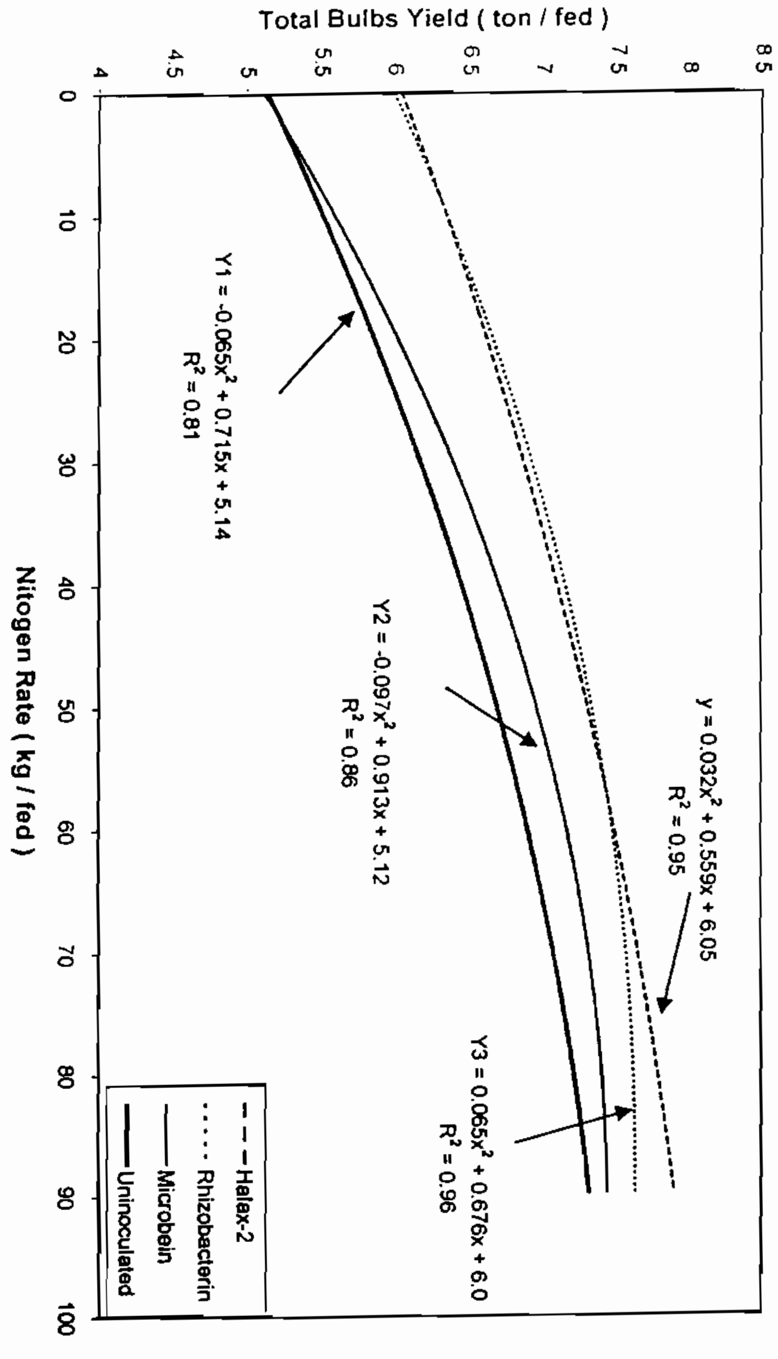

Table (6): Experimental and predicted bulbs yield of onion as affected by rates of N application and biofertilizer types in 1999/2000 and 2000/2001 seasons.

Season 1999/2000															
Yield (ton/fed.)				Yield (ton/fed.)				Yield (ton/fed.)				Yield (ton/fed.)			
Treatments		Exp	Pre	Treatments		Exp	Pre	Treatments		Exp	Pre	Treatments		Exp	Pre
Uninoculated	N_0	5.0	5.1	Microebein	N_0	5.2	5.3	Rizobacterin	N_0	5.7	5.8	Halex-2	N_0	5.5	5.6
	N_1	5.9	5.7		N_1	6.4	6.1		N_1	6.5	6.4		N_1	6.7	6.6
	N_2	6.1	6.2		N_2	6.5	6.7		N_2	7.1	7.0		N_2	7.4	7.3
	N_3	6.4	6.6		N_3	6.9	7.1		N_3	7.1	7.4		N_3	7.5	7.7
	N_4	7.3	6.8		N_4	8.0	7.4		N_4	7.8	7.8		N_4	7.9	7.9
	N_5	7.0	6.9		N_5	7.4	7.4		N_5	7.7	7.9		N_5	7.9	7.8
R= 0.954** SE= 0.233				R= 0.945** SE= 0.302				R= 0.980** SE= 0.181				R= 0.991** SE= 0.137			
Season 2000/2001															
Yield (ton/fed.)				Yield (ton/fed.)				Yield (ton/fed.)				Yield (ton/fed.)			
Treatments		Exp	Pre	Treatments		Exp	Pre	Treatments		Exp	Pre	Treatments		Exp	Pre
Uninoculated	N_0	4.8	5.1	Microebein	N_0	4.8	5.1	Rizobacterin	N_0	6.9	6.0	Halex-2	N_0	6.9	6.0
	N_1	4.5	5.8		N_1	6.5	5.9		N_1	6.5	6.6		N_1	6.6	6.6
	N_2	6.2	6.3		N_2	6.7	6.6		N_2	7.3	7.1		N_2	7.2	7.0
	N_3	6.4	6.7		N_3	6.6	7.0		N_3	7.3	7.4		N_3	7.1	7.4
	N_4	7.2	7.0		N_4	7.3	7.2		N_4	7.5	7.7		N_4	7.8	7.8
	N_5	7.0	7.1		N_5	6.7	7.3		N_5	7.7	7.8		N_5	7.9	8.1
R= 0.907* SE= 0.361				R= 0.925** SE= 0.366				R= 0.825* SE= 0.437				R= 0.874* SE= 0.406			

*, ** Significant at $P< 0.05$ and 0.01 levels, respectively

The optimum yield (Y_{opt}.)

Substitution for "n" by the values of N_{pot}. in the eqs. 2-9 (Table 7), the corresponding optimum yields Y_{opt}. of onion bulbs were 6.9 , 7.4 , 7.9 and 7.9 Ton fed^{-1} in the first season at uninoculated, Microbein, Rhizobacterin and Halex-2, respectively whereas the optimum yield in the second season were 7.1 , 7.2 , 7.7and 8.4 at uninoculated, Microbein, Rhizobacterin and Halex-2, respectively.

Net Returns of Onion Bulbs Yield Under Nitrogen Application and Biofertilization:

Net returns from optimum yield of onion bulbs yield received optimum levels of N fertilization in the two seasons were calculated and are presented in Table 7.

Table (7): Values of optimum rates of N fertilizer, optimum yields and net returns for onion cultivar's (Giza 20) as affected by different biofertilizer types in 1999/200 and 2000/2001 seasons.

Treatments	N_{opt} (units fed^{-1})	Y_{opt} (ton fed^{-1})	Net returns EP fed^{-1}
1999/2000			
Uninoculated	4.7	6.9	3228
Microbein	4.2	7.4	3501
Rhizobacterin	5.2	7.9	3706
Halex-2	3.8	7.9	3769
2000/2001			
Uninoculated	4.8	7.1	3324
Microbein	4.2	7.2	3401
Rhizobacterin	4.5	7.7	3637
$Halex_2$	7.3	8.4	3861

Avg. price of 1 ton of onion bulbs = 500 EP EP = Egyptian pounds
Avg. price of a unit of nitrogen fertilization (18 kg N) = 45 EP.
Avg. price of a package of biofertilizer inoculation for 1 fed = 10 EP.

The results indicated that, the inoculation of onion seedlings with any of the biofertilizer used was associated with higher values of net returns than the uninoculated seedlings in both seasons. The net returns were, 3228, 3501, 3706 and 3769 in the first season for uninoculated, microbein, Rhizobacterin and Halex-2 treatments respectively, whereas, the corresponding values in the second season were 3324, 3401, 3637 and 3861 at uninoculated, Microbein, Rhizobacterin and Halex-2, respectively. Thus, it is clear that Halex-2 was the most effective biofertilizer and mineral N application was more profitable when coupled with the Biofertilizer Halex-2 than to the other biofertilizers. These results are in agreement with those of Ghoneim and Abd El-Razik (1999); Abd El-Fattah and Arisha (2000) and Gabr *et al.* (2001).