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INFLUENCE OF BIOFERTILIZER AND MINERAL NITROGEN ON ONION GROWTH, YIELD AND QUALITY UNDER CALCAREOUS SOIL CONDITIONS

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ABSTRACT

Two field experiments were executed during the winter seasons of 2004/2005 and 2005/2006 at Nubaria Agricultural Research Station Farm to investigate the influence of inoculation with a mixture of N-fixing bacteria (*Azospirillum*, *Azotobacter* and *klebsiella*), biofertilizer (Halex 2) alone or combined with four levels of nitrogen (00, 30, 60 and 90 kg N/ fed.), on growth, yield components and bulb quality of onion Giza 20 cv. The results revealed that increasing mineral nitrogen fertilization levels led to significant increases on plant height and number of leaves. Average bulb weight, and marketable and total bulb yield increased also by increasing N-levels. Number of days to bulb maturity and total soluble solids (T.S.S) of mature bulbs showed some significant effects in the first season only; whereas, bulb quality parameters, in terms of percentages of single and double bulbs, bolters and sprouted bulbs, did not reflect clear effects. Inoculation of onion transplants with Halex 2 significantly, improved onion bulb yield and its components (average bulb weight and marketable yield), in both seasons, and accelerated the maturity of onion bulbs in the first season; but, did not significantly influence vegetative growth and bulb quality characters (plant height, number of leaves, and percentages of single and double bulbs, bolters, T.S.S and sprouted bulbs). Some clear interaction effects between mineral N-levels and Halex 2 inoculation were reflected on the general performances of vegetative growth, yield potential and bulb quality traits. The best treatment combination appeared to be that of the

moderate level of mineral N (60 kg N/fed.) and biofertilizer (Halex 2) inoculation treatment, which gave the maximum marketable yield and total bulb yield under calcareous soil conditions at Nubaria region. So the use of Halex 2 can replace 1/3 of the used chemical nitrogen fertilizer and, consequently, improves the economics of onion production.

Key words: Onion, biofertilizer (Halex 2), mineral N-fertilizer, bulbs yield and quality.

INTODUCTION

Onion (*Allium cepa* L.) is one of the most popular and widely consumed vegetables. In Egypt, it occupies an important position among vegetable crops due to its multifarious use as local fresh consumption, food processing and exportation; either as fresh bulbs or dehydrated slices.

Recently, onion crop showed an increasing importance particularly in the new reclaimed soils including calcareous soils, at different regions of Egypt, as in Upper Egypt and Nubaria region, which seemed to be mostly free from epidemic soil diseases; such as white rot disease that causes serious problems for Egyptian onion exportation (Farghali and Abo Zeid, 1995; and Ashry and Yaso, 2006). However, calcareous soils have their own problems; such as increased soil compaction, poverty in organic matter and low nutrients availability (Khalaf and Taha, 1988). From another point, the excessive use of inorganic fertilizers causes ground water contamination and environmental hazards, and represents the major factor in raising crop production cost (Barakat and Gaber, 1998; and El-Ghinbihi and Ali, 2001).

Biofertilization methods played an important role in plant nutritional requirements; since biofertilizers were reported to enhance crop productivity through improving plant nutrition, enhancement of nutrients availability, nitrogen fixation, phosphate solubilization, and plant hormone production, (Frommel *et al.*, 1993; and Lazarovits and Nowak, 1997). Accordingly, they may be considered as a suitable solution for nutrients availability problems in such calcareous soils.

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The nutritional status of onion plants plays a fundamental importance in determining growth, yield and quality of bulbs since onion plant is very sensitive to nutritional balance. This might be due to its shallow root system and high productivity; besides, it is a long season crop.

Among the nutrients required for the shallow rooted onion plants, in large amounts; nitrogen is the most essential factor in enhancing growth, bulb development, yield performance and bulb quality, primarily, by controlling leaf growth (Gamiely *et al.*, 1991; Brewster, 1994; Drost *et al.*, 2002 and Woldetsadik *et al.*, 2003). Optimum N supply is necessary for maximum onion production and performance (Brown *et al.*, 1988 and Gamily *et al.*, 1991); whereas, inadequate or low N levels increase the incidence of onion bolting and limit bulbs yield (Diaz-Perez *et al.*, 2003). However, super-optimal N application rate can over-stimulate growth late in the season; resulting in promoted foliage growth, delayed crop maturity; and contribute to poor bulb quality with increased storage losses (Brown *et al.*, 1988; Brewster, 1994 and Woldetsadik *et al.*, 2003). Hence, the judicious application of mineral nitrogen fertilizer is an important cultural practice to improve the yielding ability and bulb quality of onion plants. Under these circumstances, supplementing the mineral N fertilizer with untraditional organic source, particularly, those of microbial origin are very important, especially under calcareous soils conditions.

During last two decades, various attempts were done to replace all or part of chemical nitrogen fertilizer, using microbial isolates to fix atmospheric nitrogen in the soil in an available form (El-Afifi *et al.* 2002). In this tendency, many investigators demonstrated that using untraditional fertilizers, especially biofertilizers (non-symbiotic N_2-fixing bacteria) including Halex 2, reflected positively effects on growth, yield and quality of most important vegetable crops such as tomato (Barakat and Gabr, 1998), potato (El-Gghinbihi and Ali, 2001), cabbage (El-Afifi *et al.*, 2002), globe artichoke (Ghoneim, 2005), in addition to onion (El-Desuki *et al.*, 2006a).

Unfortunately in Egypt, there is still clear lacking information concerning influences of inoculation, using N_2-fixing bacteria isolates on onion crop grown under Delta soils or newly reclaimed (sandy or calcareous) soils. Therefore, the present study was designed to investigate the effectiveness of the inoculation with Halex 2 biofertilizer under varying levels of mineral nitrogen fertilizer and to study their interaction effects on plant growth, maturity, bulb yield and its component, and bulb quality of onion cultivar Giza 20; under new reclaimed calcareous soil conditions at Nubaria region; aiming to reduce or compensate mineral nitrogen fertilization without causing any undesirable effects on yield and quality of onion.

MATERIALS AND METHODS

The current study was conducted in newly reclaimed calcareous soil at Nubaria region, during the two winter seasons of 2004/2005 and 2005/2006. Prior to initiating the experiments, soil samples were collected from two depths (0-20 and 20-40 cm) of the experimental sites and analyzed according to the procedures of Page *et al.* (1982). The results of the analysis of both experimental fields are listed in Table 1.

Uniform and healthy transplants (about 75 days old) of the onion cultivar Giza 20 were transplanted on December 20, 2004 and on December 19, 2005 in the first and second growing seasons, respectively.

Mineral nitrogen fertilizer treatments contained three different levels (30, 60 and 90 kg N/fed.) in addition to the unfertilized control treatment. Nitrogen amount of each rate, in the form of ammonium nitrate (33.5% N), was divided into three equal portions and were side dressed at 30, 60 and 90 days after transplanting.

Table 1: Some important physical and chemical properties of the two experimental sites, in 2004/2005 and 2005/2006 winter seasons.

Soil characters	2004/2005 season		2005/2006 season	
Soil depth (cm)	0-20	20-40	0-20	20-40
Soil pH	8.48	8.25	8.26	8.28
EC, dS/m	3.86	4.58	1.93	2.09
Soil texture class	Sandy loam		Sandy loam	
CaCO3 (%)	25.85	24.91	23.21	26.44
O.M. (%)	0.24	0.26	0.27	0.21
Available macro-nutrients:				
N (ppm)	46.38	33.72	46.13	31.74
P (ppm)	4.14	3.65	2.74	2.12
K (ppm)	91.36	84.31	87.26	67.48
Available micro-nutrients:				
Zn (ppm)	0.21	0.17	1.32	1.19
Fe (ppm)	3.40	2.60	1.22	1.20
Mn (ppm)	0.94	0.83	1.62	1.51

Biofertilizer treatments included inoculating onion transplants with Halex 2 and the non-inoculated control treatment. Therefore, there were then eight treatment combinations as shown in Table 2.

Table 2: The studied experimental treatment combinations.

Treat. No	Type of treatment
1-a	00 (without N) + without Halex 2 inoculation
1-b	00 (without N) + with Halex 2 inoculation
2-a	30 kg N/fed. + without Halex 2 inoculation
2-b	30 kg N/fed. + with Halex 2 inoculation
3-a	60 kg N/fed. + without Halex 2 inoculation
3-b	60 kg N/fed. + with Halex 2 inoculation
4-a	90 kg N/fed. + without Halex 2 inoculation
4-b	90 kg N/fed. + with Halex 2 inoculation

Onion transplants of Giza 20 cv. were inoculated by dipping the roots to sheath area in cell suspension of the Halex 2 at the rate of one kg/fed., for about 30 minutes, just before transplanting. Transplants of the non-inoculated control treatment were dipping in distilled water. The biofertilizer Halex 2 (a mixture of growth promoting of non-symbiotic N-fixing bacteria of genera *Azospirillum*, *Azotobacter* and *klebsiella*) was supplied by the Biofertilization Unit, Plant Pathology Department, Fac. of Agric., Alex. Univ., and used as a mixed biofertilizer in this investigation.

In both seasons, the experiment was carried out using a split-plot system in a randomized complete blocks design, with three replications. The main plots were allocated to the four nitrogen levels, whereas, the two inoculation (with or without Halex 2) treatments were randomly distributed in the sub-plots. The experimental sub-plot size was 7.0 m^2; each consisting of four rows, 50 cm wide and 3.5 m long. Giza 20 cv. transplants were planted on both sides of the row at 10 cm spacing.

All experimental plots received identical levels of basic phosphorus and potassium fertilization at the rates of 45 kg/fed. as calcium super phosphate (15.5% P_2O_5) and 48 kg/fed. as potassium sulphate (48.5% K_2O), which were applied during soil preparation. Other normal agricultural practices, commonly used in commercial onion crop production under calcareous soil conditions at Nubaria region, were performed.

Data recorded:-

1- Vegetative growth characters

At 120 days from transplanting a random sample of 15 plants were taken from each experimental unit to determine plant height (cm) and number of tubular leaves per plant.

2- Number of days to bulbs maturity

Number of days from transplanting to bulbs maturity was counted. Maturity stage was determined as 50% of the plants in each sub-plot fell down (50% top-down).

3- Bulbs yield and its component:-

At harvest, all onion plants in each experimental sub-plot were pulled and the following data were recorded:-

a- Total bulb yield (Ton/fed.)

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All harvested bulbs in each sub-plot were weighed in kg., then converted to ton/fed.

b- Marketable yield (Ton/fed.)

It was determined as the weight of single bulbs yield (kg/plot), then converted to ton/fed.

c- Average bulb weight (g)

It was calculated by dividing the weight of single bulbs by their number.

4- Bulb quality parameters:-

a- Percentage of single and double bulbs

It was calculated by dividing number of single and double bulbs by the total number of bulbs per sub-plot x 100.

b- Percentage of bolters

Plants that showed annual bolting in each sub-plot were counted and percentages of bolters were calculated.

c- Percentage of sprouted bulbs

All healthy onion bulbs yield from each experimental plot was kept under common storage conditions at Nubaria region for six months. Then, the percentage of sprouted bulbs was estimated.

d- Total soluble solids content (T.S.S. %) of mature bulbs

After the storage period, T.S.S. content of mature bulbs (%) was determined by using a hand refractometer.

All obtained data were statistically analyzed using COSTAT computer program for statistics. The Duncan test at 5% level of probability was used to compare the means of the various treatments, as elucidated by Waller and Duncan (1969).

RESULTS AND DISCUSSION

1- Vegetative growth characters:-

Data presented in Table (3) showed that application of mineral N fertilizer reflected some significant increases on plant height and number of leaves per plant, relative to the unfertilized control treatment, in both seasons, with the exception of leaves number in the first season which showed insignificant differences. The highest N level; (90 kg N/fed.) was more effective on increasing plant height and number of leaves characters. The enhancing effect of N on plant growth might be attributed to its vital contribution to several biochemical processes (chlorophyll, enzymes and proteins synthesis) related to vegetative growth in the plants, and to its active role on assimilating the photosynthetic reactions (Marschner, 1994 and El-Desuki *et al.*, 2006a). Also, adding mineral N fertilizer to the soil could increase the capacity of plant to absorb more nutrients, which might be related to the increased root surface per unit of soil volume and rate of nutrients uptake (Badr and El-Shebiny, 1999).

Inoculation of onion Giza 20 cv. transplants before transplanting with the Halex 2 biofertilizer gave insignificant increases on plant height and number of leaves per plant compared with control treatment (without inoculation) in both seasons (Table 3).

Data listed in Table (3) show the influences of the interaction treatments between the different levels of mineral N and biofertilizer (Halex 2) inoculation on vegetative growth of onion plants. Results declared that vegetative growth parameters (i.e., plant height and number of leaves per plant) were significantly affected by the interaction between the two factors in both growing seasons. The highest values of vegetative growth traits were recorded with onion plants that received the highest level of mineral N fertilizer (90 kg N/fed.) in addition to Halex 2 inoculation treatment; whereas, the lowest values were detected on control treatment (without mineral N + without Halex 2 inoculation) in both seasons. This result might be due to the combined roles of N-fertilizer for promoting the vegetative growth of onion plants and that of biofertilizer (Halex 2) on increasing the availability of nutrients, particularly N element, to plant absorption; which encouraged the vegetative growth of onion plants, as previously mintioned. Similar findings were reported on potato plants by El-Ghinbihi and Ali (2001), who indicated that inoculation of potato seed tubers with biofertilizer Halex 2 gave a significant increase on plant height, number of branches and leaves per plant, as the mineral N level was increased, due to the role of N on encouraging plant growth.

2- Number of days to bulbs maturity:-

Data listed in Table (3) illustrated that the application of mineral N decreased number of days to maturity; viz., accelerated bulbs maturity. In this line, the highest N level (90 kg N/fed.) was more effective in decreasing number of days to maturity compared with the control (non fertilized treatment). However, the differences between all nitrogen applied levels were not found significant in the second season. The obtained results are in disagreement with those of Woldetsadik *et al.* (2003), who reported that additional nitrogen promoted foliage growth, delayed bulb growth and development. Meanwhile, Drost *et al.* (2002) stated that N rate had no influence on bulb maturity.

Inoculation of onion transplants with the biofertilizer Halex 2 decreased number of days to bulbs maturity; viz., hastened bulbs maturity; compared with non inoculation. This result was true in the first season (2004/2005); whereas, in 2005/2006 season, the inoculation of onion plants did not reflect any significant effect on this trait (Table 3).

The pronounced influences of Halex 2 inoculation might be explained on the basis that Halex 2 contained three different genera of non-symbiotic N-fixing bacteria (*Azotobacter*, *Azospirillum* and *Klebsiela*) and that the two first strains of these bacteria (*Azotobacter* and *Azospirillum*) produced adequate amounts of indole acetic acid (IAA), gibberellins and cytokinins, which increased the surface area per unit root length and enhanced the root hair branching with an eventual increase in acquisition of nutrients from the soil, as indicated by Jagnow *et al.* (1991).

The interaction between mineral N-levels and biofertilizer (Halex 2) had some significant influences on decreasing number of days to maturity, compared with the control treatment (without inoculation + without N fertilizer) but only in the first growing season (Table 3).

Table 3: Vegetative growth characters of onion plants and number of days to bulb maturity, as affected by different levels of mineral-N fertilizer, biofertilizer (Halex 2) inoculation and their interactions, during the two winter seasons of 2004/2005 and 2005/2006.

Treatments	2004/2005 season			2005/2006 season		
	Plant height (cm)	No. of Leaves per plant	No. of days to bulb maturity	Plant height (cm)	No. of Leaves per plant	No. of days to bulb maturity
Mineral N levels (kgN/fed.)						
0	54.33c	7.25	162.83a	64.56b	7.40b	149.00
30	58.03b	7.27	158.83ab	71.96a	7.92a	147.57
60	59.93ab	7.30	155.83ab	74.90a	8.03a	148.00
90	61.93a	7.45	153.83b	72.90a	8.30a	148.83
		N.S				N.S***
Biofertilizer (Halex 2)						
Bf H0*	57.28	7.22	159.42a	70.40	7.82	148.70
Bf H1**	59.83	7.42	156.25b	71.76	8.01	148.00
	N.S	N.S		N.S	N.S	N.S
Interact. (N + Halex 2)						
0 + Bf H0	52.47b	7.10b	165.67a	63.73c	7.37c	149.67
0 + Bf H1	56.20ab	7.40ab	160.00bc	65.40c	7.43bc	148.33
30 + Bf H0	56.20ab	7.23ab	160.67b	70.80b	7.87bc	146.47
30 + Bf H1	59.87a	7.30ab	157.00bcd	73.13ab	7.97abc	148.67
60 + Bf H0	58.73ab	7.13ab	156.00bcd	74.20ab	8.00abc	149.67
60 + Bf H1	61.13a	7.47ab	155.67cd	75.60a	8.07ab	146.33
90 + Bf H0	61.73a	7.40ab	155.33cd	72.87ab	8.03ab	149.00
90 + Bf H1	62.13a	7.50a	152.33d	72.93ab	8.57a	148.67
						N.S

***Bf H0 = without biofertilizer (Halex 2) inoculation (control)**
****Bf H1 = with biofertilizer (Halex 2) inoculation**
Values marked with the same letter(s), within a comparable group of means, do not significantly differ, using Duncan test at 0.05 probability level.
*****Values are not significant at 0.05 probability level.**

The combinations of 90 kg N/fed. with the inoculation by Halex 2 treatment gave the best values for decreasing number of days to bulb maturity. However, the differences between the different combinations of N-levels and Halex 2 were not found significant in the season of 2005/2006. The directed differences; in the response of onion plants to different levels of mineral nitrogen and the biofertilizer Halex 2 inoculation, each alone or in combinations; between the two growing seasons on bulbs maturity might be attributed to the high content of experimental soil from available K element in the first season relative to the second one, as illustrated in Table (1). The results reported by Yaso and Moursy (2007, in press) indicated that K had clear effects on hastening bulb maturity, and noticed that increasing potassium fertilizer rates up to 48 kg K_2O/fed. decreased number of days to bulb maturity. The later mentioned effect might be related to the role of potassium on promotion of enzymes activity and enhancing the translocation of assimilates and protein synthesis within different plant organs (El-Desuki *et al.*, 2006b).

3- Bulbs yield and its components:-

Average bulb weight, marketable and total bulbs yield

Data listed in Table (4) show the influences of the studied levels of mineral nitrogen on average bulb weight, marketable yield as well as total bulbs yield, which reflected the gradual increases with increasing the used level of N fertilizer. The moderate and the highest N-levels (60 and 90 kg N/fed.) produced significant high values in the three characters with increase percentages of (12.27, 8.81%), (15.28, 21.70%) and (18.41, 22.36%) for average bulb weight, marketable and total yields compared with unfertilized treatment, in the first and second season, respectively. These findings could support the explanation of Khalil *et al.* (1988), who stated that N application enhanced metabolic activities within the plant, improved vegetative growth and thereby encouraged much more metabolites to be stored in the bulbs as storage organs. The obtained results were noticed to agree with those reported by Haggag *et al.* (1986), Hanna-alla *et al.* (1991), Al-Moshileh, (2001), Drost *et al.* (2002), Diaz-Perez *et al.*, (2003) and El-Desuki *et al.* (2006a), who reported that the total onion bulbs yield and its components were improved as a result of increasing the levels of mineral N fertilizer. However, Woldetsadik *et al.* (2003) illustrated that increasing N application up to 150 kg/ha did not significantly affect bulb yield, but reduced the number of marketable bulbs of shallot plants.

Results presented in Table (4) pointed out that inoculation of onion Giza 20 cv. transplants with the Halex 2, significantly, increased average bulb weight, marketable and total yield, comparing with the non inoculated treatment. The increasing percentages were (16.39, 4.72%), (10.17, 4.33%) and (12.38, 3.84%) for average bulb weight, marketable and total yield in both seasons, respectively. The enhancing effect of using the biofertilizer Halex 2 might be attributed to supporting the growth of onion plants with available nitrogen and the role of nitrogen in increasing the leaf area which enhance the photosynthetic rate and ended with increasing formation of the carbohydrates and its translocation down to the bulb (Al-Moshileh, 2001).

Table 4: Average onion bulb weight, marketable and total bulb yield as affected by different levels of mineral-N fertilizer, biofertilizer (Halex 2) inoculation and their interactions, during the two winter seasons of 2004/2005 and 2005/2006.

Treatments	2004/2005 season			2005/2006 season		
	Bulb weight (g)	Marketable yield (Ton/fed.)	Total yield (Ton/fed.)	Bulb weight (g)	Marketable yield (Ton/fed.)	Total yield (Ton/fed.)
Mineral N levels (kg N/fed.)						
0	73.13b	15.12b	15.21b	83.17b	10.23b	10.43b
30	73.72b	15.52b	15.57b	85.50ab	11.41ab	11.99a
60	78.45ab	17.26a	18.01a	87.50a	12.45a	12.75a
90	82.10a	17.43a	17.48a	90.50a	12.13a	12.62a
Biofertilizer (Hal. 2)						
Bf H0*	71.03b	15.54b	15.61b	84.67b	11.31b	11.73b
Bf H1**	82.67a	17.12a	17.53a	88.67a	11.80a	12.17a
Interact. (N + Hal. 2)						
0 + Bf H0	66.77c	14.58b	14.65b	80.33e	9.85e	10.07f
0 + Bf H1	79.50abc	15.66ab	15.77b	86.00cd	10.61de	10.78e
30 + Bf H0	67.37bc	14.77b	14.83b	84.00d	11.25cd	11.78d
30 + Bf H1	80.07abc	16.26ab	16.31b	87.00bcd	11.57bc	12.20c
60 + Bf H0	73.67abc	16.28ab	16.37b	85.00d	12.26ab	12.66ab
60 + Bf H1	83.23ab	18.24a	19.65a	90.00ab	12.63a	12.84a
90 + Bf H0	76.33abc	16.52ab	16.56b	89.33abc	11.88abc	12.36bc
90 + Bf H1	87.87a	18.33a	18.40a	91.67a	12.39ab	12.87a

***Bf H0 = without biofertilizer (Halex 2) inoculation (control)**
****Bf H1 = with biofertilizer (Halex 2) inoculation**
Values marked with the same letter(s), within a comparable group of means, do not significantly differ, using Duncan test at 0.05 probability level.

Maximum averages bulb weight (87.87, 91.67 g), marketable yields (18.33, 12.63 ton/fed.) and bulbs total yields (19.65, 12.87 ton/fed.) in both seasons, respectively; were recorded with treatment combinations between the moderate or high levels of mineral N fertilizer (60 or 90 kg N/fed.) and Halex 2 inoculation; which reflected increasing percentage of (31.60, 14.12%) for average bulb weight, (25.72, 28.22%) for marketable yield and (34.13, 27.80%) for total bulb yield, in both seasons, respectively; comparing with the control treatment (without N fertilizer + without Halex 2 inoculation).

It is clear from the data in Table (4) that the combination of the moderate level of mineral-N (60 kg N/fed.) with the inoculation by Halex 2 treatment did not significantly differ from the combination of the highest N-level (90 kg N/fed.) with the inoculation by Halex 2 treatment on average bulb weight, marketable and total bulbs yield in both seasons and, sometimes, the former treatment combination had superior influences as on total yield and marketable yield in the first and second year, respectively. Therefore, the obtained results ment that 60 kg N/fed. might be sufficient to meet the requirements of onion plants Giza 20 cv. when the transplants were inoculated with the biofertilizer (Halex 2), under the present investigation conditions. These results seemed to be in harmony with those reported by El-Ghinbihi and Ali (2001) on potato, and by Ghoneim (2005) on globe artichoke, who stated that the highest mean values in average tuber weight, total tuber yield, average weight of heads and total heads yield were obtained from the use of a moderate level of nitrogen fertilizer (75% of the recommended N level or 90 kg N/fed.) combined with the biofertilizer Halex 2 treatment; in both crops, each in order.

4- Bulbs quality parameters:-

a- Percentages of single, double bulbs, and bolters

The data in Table (5) showed insignificant differences as a result of using different levels of mineral-N fertilizer or biofertilizer (Halex 2) inoculation as well as for their interaction effects on the percentages of single and double bulbs or bolters in the two growing seasons under the present investigation conditions.

b- Percentage of sprouted bulbs

Data in Table (6) revealed insignificant variations on the percentage of sprouted bulbs character after a storage period of six months, as a result of using N fertilizer or biofertilizer Halex 2 inoculation treatments, each alone or in combinations, in both seasons. This result could indicate that onion cultivar Giza 20 is characterized by having a high capability to control sprouting phenomena under the local storage conditions at Nubaria region.

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c- Total soluble solids (T.S.S) content of mature bulbs

With respect to percentage of total soluble solids content, data listed in Table (6) show that the highest T.S.S. content was obtained when mineral N was added at the highest level (90 kg N/fed.) in the first season. However, in the second one, the differences among the varying levels of mineral N were not found significant. The positive N effect seemed to be in accordance with that of Haggag *et al.* (1986), who found similar findings with the same level of mineral N (90 kg N/fed.), but with increasing N level up to 150 kg N/fed. decreased T.S.S. content. In the same line of this study, the data of Moursy *et al.* (2007) showed that increasing the level of N fertilizer to 80 kg N/fed. resulted in about 8.5% increase in the T.S.S content as compared to the level of 40 kg N/fed. On the contrary, Hanna-alla *et al.* (1991) concluded that increasing nitrogen levels up to 120 kg N/fed. decreased the percentage of T.S.S. content of mature bulbs Giza 20 cv. This decrease in the percentage of T.S.S. content in mature onion bulbs with the increasing of nitrogen supply (120-150 kg N/fed.) might be due to the increase of moisture contents of the fertilized plants cells.

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Table 5: Percentages of single and double bulbs as well as bolters plants as affected by different levels of mineral-N fertilizer, biofertilizer (Halex 2) inoculation and their interactions, during the two winter seasons of 2004/2005 and 2005/2006.

Treatments	2004/2005 season			2005/2006 season		
	Single bulbs (%)	Double bulbs (%)	Bolters (%)	Single bulbs (%)	Double bulbs (%)	Bolters (%)
Mineral N levels (kg /fed.)						
0	99.45	0.38	0.17	96.67	1.65	1.68
30	99.50	0.22	0.28	96.05	2.83	1.12
60	99.57	0.30	0.13	96.48	2.72	0.80
90	99.70	0.20	0.10	96.98	2.23	0.78
	N.S***	N.S	N.S	N.S	N.S	N.S
Biofertilizer (Halex 2)						
Bf H0*	99.48	0.29	0.23	95.98	2.50	1.27
Bf H1**	99.63	0.26	0.14	97.11	1.96	0.93
	N.S	N.S	N.S	N.S	N.S	N.S
Interaction (N + Halex 2)						
0 + Bf H0	99.40	0.33	0.23	96.33	2.02	1.65
0 + Bf H1	99.47	0.43	0.10	97.00	1.27	1.73
30 + Bf H0	99.37	0.27	0.37	95.40	2.97	1.63
30 + Bf H1	99.63	0.17	0.20	96.70	2.70	0.60
60 + Bf H0	99.50	0.33	0.17	95.70	2.60	0.70
60 + Bf H1	99.63	0.27	0.10	97.27	1.83	0.90
90 + Bf H0	99.60	0.23	0.17	96.50	2.43	1.07
90 + Bf H1	99.80	0.17	0.03	97.47	2.03	0.50
	N.S	N.S	N.S	N.S	N.S	N.S

***Bf H0 = without biofertilizer (Halex 2) inoculation (control)**
****Bf H1 = with biofertilizer (Halex 2) inoculation**
Values marked with the same letter(s), within a comparable group of means, do not significantly differ, using Duncan test at 0.05 probability level.
*****Values are not significant at 0.05 probability level.**

It was observed that Biofertilizer (Halex 2) inoculation treatments had insignificant influences on the percentage of T.S.S content of mature bulbs in the two studied seasons (Table 6).

The interaction effects between mineral N-levels and the biofertilizer Halex 2 had some significant influences on T.S.S content (%) of mature bulbs. Data in Table (6) illustrated that the treatment combination of 90 kg N/fed. with the inoculation by Halex 2 gave the highest mean values for T.S.S content of mature bulbs compared with control treatment (without mineral N + without Halex 2 inoculation). However, the differences between combinations of moderate N-level

(60 kg N/fed.) with Halex 2 and high N-level (90 kg N/fed.) with Halex 2 were not found significant, in both growing seasons. A similar tendency was noticed with the results of El-Desuki *et al.* (2006a), who found positive influences for the interaction effects of mineral fertilizers (NPK) and biofertilizers (Nitrobien or Phosphorien) treatments on the percentage of T.S.S content of Giza 20 cv. mature bulbs.

Table 6: Percentages of sprouted bulbs and total soluble solids (T.S.S) content of mature bulbs as affected by different levels of mineral-N fertilizer, biofertilizer (Halex 2) inoculation and their interactions, during the two winter seasons of 2004/2005 and 2005/2006.

Treatments	2004/2005 season		2005/2006 season	
	Sprouted bulbs (%)	T.S.S content (%)	Sprouted bulbs (%)	T.S.S content (%)
Mineral N levels (kg N/fed.)				
0	0.50	10.23b	1.16	10.12
30	0.33	11.22ab	1.13	10.82
60	0.16	11.47ab	1.23	10.97
90	0.16	11.82a	1.66	10.87
	N.S***		N.S	N.S
Biofertilizer (Halex 2)				
Bf H0*	0.42	10.87	1.50	10.44
Bf H1**	0.16	11.50	1.10	10.95
	N.S	N.S	N.S	N.S
Interaction (N + Halex 2)				
0 + Bf H0	0.67	10.13b	1.48	9.77b
0 + Bf H1	0.33	10.33b	0.85	10.47ab
30 + Bf H0	0.33	10.80ab	1.33	10.60ab
30 + Bf H1	0.33	11.63ab	0.93	11.03a
60 + Bf H0	0.33	10.97ab	1.38	10.67ab
60 + Bf H1	0.00	11.97a	1.08	11.27a
90 + Bf H0	0.33	11.57ab	1.80	10.70ab
90 + Bf H1	0.00	12.07a	1.53	11.03a
	N.S		N.S	

***Bf H0 = without biofertilizer (Halex 2) inoculation (control)**
****Bf H1 = with biofertilizer (Halex 2) inoculation**
Values marked with the same letter(s), within a comparable group of means, do not significantly differ, using Duncan test at 0.05 probability level.
*****Values are not significant at 0.05 probability level.**

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In conclusion, the obtained results of the current study indicated that the inoculation of onion plants with biofertilizer Halex 2 and adding mineral N fertilizer led to enhancement of plant growth traits which reflected significant increments on marketable and total bulbs yields and improved quality characteristics.

The results revealed also that the most economical treatment combination, which gave the highest mean values of bulb weight, marketable and total bulbs yields was that of the moderate level of mineral-N (60 kg N/fed.) with the inoculation by biofertilizer (Halex 2). Moreover, the use of biofertilizer (Halex 2) in onion fields can be considered as a partial good alternative to replace some of the chemical nitrogen fertilizer application (for about 1/3 of the quantity), and consequently can reduce the total production cost of onion crop; in addition to reducing the environmental pollution.

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الملخص العربي

تأثير السماد الحيوي و السماد النيتروجيني المعدني علي نمو ومحصول و جودة البصل تحت ظروف الأراضي الجيرية

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أجريت تجربتان حقليتان تحت ظروف الأراضي الجيرية بمزرعة محطة بحوث النوبارية خلال الموسمين الشتويين 2005/2004 و 2006/2005 لبحث تأثير مدي إستجابة نباتات البصل صنف جيزة 20 للتلقيح بمخلوط من البكتريا (*Azospirillum*, *Azotobacter* and *klebsiella*) المشجعة لتثبيت الآزوت الجوي من السماد الحيوي هالكس 2 منفردا أو مشتركا مع أربعة مستويات من السماد الآزوتي المعدني (صفر ، 30 ، 60 ، 90 كجم ن/فدان) علي صفات النمو والمحصول ومكوناته وكذلك صفات الجودة للأبصال الناتجة.

ولقد عكست النتائج الآتي:

أن زيادة مستويات السماد الآزوتي المعدني تقود إلي زيادة معنوية في إرتفاع النبات وعدد الأوراق لكل نبات. متوسط وزن البصلة والمحصول القابل للتسويق والمحصول الكلي إزداد أيضا بزيادة مستويات السماد الآزوتي المعدني. عدد الأيام اللازمة لنضج الأبصال ومحتوي الأبصال الناضجة من المواد الصلبة الذائبة الكلية أظهرت بعض التأثيرات المعنوية خلال موسم النمو الأول. في حين أن قياسات الجودة متمثلة في النسب المئوية للأبصال المفردة والأبصال المزدوجة وللإزهار الحولي والأبصال المزرعة لم تعكس أي تأثيرات واضحة.

إن معاملة تلقيح شتلات البصل بالسماد الحيوي هالكس 2 قد أدت إلي ظهور تحسين معنوي واضح علي محصول البصل ومكوناته (متوسط وزن البصلة والمحصول القابل للتسويق) في كلا الموسمين، كما أسرعت من نضج الأبصال في موسم النمو الأول. بينما لم تظهر أي تأثيرات معنوية علي صفات النمو الخضري وجودة الأبصال الناتجة (إرتفاع النبات وعدد الأوراق لكل نبات والنسب المئوية لكل من الأبصال المفردة والأبصال المزدوجة وللإزهار الحولي ومحتوي الأبصال الناضجة من المواد الصلبة الذائبة الكلية ونسبة الأبصال المزرعة.

بعض تأثيرات التفاعل بين مستويات السماد الآزوتي المعدني والتلقيح بالسماد الحيوي هالكس 2 قد أدت إلي ظهور تأثيرات معنوية واضحة علي كل من صفات النمو الخضري والمحصول ومكوناته وجودة الأبصال الناتجة.

وجد أن إضافة المستوي المتوسط من السماد الآزوتي المعدني (60 كجم ن/فدان) مع التلقيح الحيوي بسماد هالكس 2 كانت أفضل المعاملات كفاءة، حيث تحققت أعلي قيمة لكل من المحصول القابل للتسويق ومحصول البصل الكلي تحت ظروف الأراضي الجيرية بمنطقة النوبارية. لذلك فإن إستخدام السماد الحيوي هالكس 2 يمكن أن يحل محل ثلث الكمية المستخدمة من السماد الآزوتي الكيماوي و بالتالي يحسن من إقتصاديات إنتاج البصل.