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Effect of Different Nitrogen and Sulphur Fertilizer Levels on Growth, Yield and Quality of Onion (*Allium cepa*, L.)

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ABSTRACT

Two field experiments were carried out at a farm in South Ghor area, Jordan, during 2004/2005 and 2005/2006 seasons to study the effect of three levels of nitrogen (100, 150 and 200 kg/ha) and three levels of sulphur (0, 50 and 100 kg/ha) on growth and productivity of onion bulbs Giza 20 cultivar using an experimental design of split plot with three replications for each treatment.

The results showed that increasing nitrogen and sulphur application rates significantly enhanced plant height, number of green leaves/plant and weight of plant and bulb at different stages of onion growth. Total yield, marketable yield, culls yield, percentage of marketable, doubles and bolters as well as total soluble solids (TSS%) were also increased with increasing the rates of nitrogen and sulphur up to 200 kg N/ha and 100 kg S/ha in both seasons, respectively; whereas the lowest percentage of pickles yield was recorded with the highest level of nitrogen and sulphur fertilizers.

In general, the application of 200 kg N/ha + 100 kg S/ha increased the total and marketable yield of onion bulbs of Giza 20 cultivar grown under similar conditions of this work.

Keywords: Onion, Nitrogen, Sulphur, Green leaves, Yield of onion, Weight of plant.

INTRODUCTION

Maximum yield and bulb weight uniformity are the two important characters in determining the marketable proportion of onion (*Allium cepa*, L.) performance (Krishnamuthy and Sharanappa, 2005). Nutrients play a significant role in improving productivity and quality of crops. Therefore, increasing the productivity of onion with a good quality is an important target for the local market.

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Nitrogen is an essential element for both growth and productivity of all plants and onion crop. The beneficial effect of nitrogen application on onion yield was noted by (Mahmoud *et al*.,2000; Tiwori *et al*.,2002; Devi *et al.*,2003; Abdel-Mawgoud *et al*.,2005). Also, (Lee-Jongatae *et al.*, 2003) in Korea Republic, applied nitrogen for onion at rates of (0, 120, 180 and 240 kg N/ha) and found that the highest values for plant height (73.2 cm) and bulb diameter (55.6 mm) were obtained at rates of 180 and 240 kg N/ha, respectively. But the highest marketable yield (22.9 t/ha) was obtained at 120 kg N/ha).

In the past few years, there has been an increased concern about the role of sulphur application as a soil amendment and as a factor of increasing fertilizer

efficiency. Sulphur as a macronutrient has a positive effect on onion and other crops (El-Shafie and El-Gamaily, 2002; Bloem *et al.,* 2004). Application of sulphur to the soil has several effects; such as reducing pH, improving soil-water relation and increasing availability of nutrients like P, Fe, Mn and Zn (Marschner, 1998). The yield of onion bulbs was also increased by the increment of S rates 0, 20 and 80 kg/ha (El-Shafie and El-Gamaily, 2002; Singh *et al.,* 1997), and at 325 kg/ha by Attia (2001), as well as Smitttle (1984) who found that sulphur application consistently increased onion pungency, while Jana and Jahangir Kabir (1992) indicated that the highest plant height (48.62 cm), number of green leaves (9.14), bulb diameter (6.13cm), weight of 10 bulbs (1.02 kg) and yield (30.69 ton/ha) were obtained at 30 kg /ha of sulphur . Similar trend was obtaind by Sharma *et al.* (2002) who found a linear increment of plant growth, bulb diameter and yield with sulphur application rate from 15 to 60 kg S/ha.

The main purpose of this study was to determine the main plot of the best rate of nitrogen fertilizer under the sub-plot of different sulphur rates as well as their interactions for maximizing bulb yield and quality of onion.

MATERIALS AND METHODS

Two field experiments were carried out during the two winter seasons of 2004/2005 and 2005/2006, at a farm in South Ghor area, to study the effect of nitrogen and sulphur fertilization levels on vegetative growth, yield and yield components of onion (*Allium cepa*, L.) cv. Giza 20. For each experiment, nitrogen and sulphur treatments were conducted in the same area.

Onion seeds were sown in the nursery on September 10^{th} and 8^{th} while transplanting took place on November 10^{th} and 5^{th} during 2004/2005 and 2004/2005 seasons, respectively. Nursery bed was prepared and planted with onion seeds and fertilized with 25 kg N/ha as ammonium nitrate (33.5% N). The chemical analysis of the experimental soil samples (Table 1) were conducted according to the procedures indicated by Jackson (1967).

The experimental design was split plot with four replications. The main plots were designed for different nitrogen fertilizer levels (100, 150 and 200 kg/ha.), while three sulphur levels (0 , 50 and 100 kg S/ha) were randomly distributed in the sub-plots. The experimental plot area was 10.5 m^2 (3.5 m in length and 3 m in width) including five ridges with 60 cm distance between ridges. Uniformed seedlings were transplanted after hardening on both sides of ridges, 7-10 cm distance. Phosphorus fertilizer in the form of super phosphate (15.5% P_2O_5) at a rate of 122 kg/ha and agricultural sulphur was used as a source of sulphur. The phosphorus and sulphur fertilizers were applied in one dose before transplanting while the nitrogen fertilizer was applied as ammonium nitrate (33.5% N) in two equal doses (one and two months after transplanting). Other practices for growing onion were conducted as recommended for onion production. This procedure was carried out for each experiment in both winter seasons.

Characters Studied

The following plant characters in both experiments were estimated according to the recommended methods as follows**:**

A. Vegetative Growth

Ten guarded plants were randomly chosen from the 2^{nd} row of each plot at 70,90 and 110 days after transplanting (DAT). The following data were recorded for each time:

1. Plant height (cm): measured from the base of swelling sheath to the top of the longest tubular blades.

2. Number of green leaves/plant.

3. Plant weight (gm): calculated as an average weight of the ten plants after root removal.

4. Bulb weight (gm): calculated by subtraction of foliage fresh weight from plant fresh weight.

B. Yield and quality of bulbs

Plants were harvested when 75% of plant tops were down and bulbs were weighed and the following data recorded.

1. Total bulb yield (t/ha): determined by weighing the harvested bulbs from each experimental plot and total yield was calculated as t/ha.

2. Marketable yield (t/ha): determined as the weight of single bulbs only for each experimental plot.

3. Culls yield (t/ha): included bulbs of less than 3 cm diameter, doubles, bolters, off-color and scallions.

C. Characteristics of bulb

1. **Percentage of marketable yield** (3-6 cm in diameter).
2. **percentage of doubles' yield.**
3. **Percentage of bolters' yield.**
4. **Percentage of pickles' yield** (less than 3.5 cm in diameter).
5. **Total soluble solids (TSS):** determined immediately after harvesting by a hand refractometer in the same representative sample of the ten bulbs according to (AOAC, 1975).

Statistical Analysis

The resulting data were subjected to analysis of variance by means of "IRRISTAT" computer software package (Snedecor and Cochran, 1980). Treatment means were compared by Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

A. Vegetative Growth

1. Plant height and number of green leaves/plant

The presented data in Tables (2 and 3) show that there were significant differences between nitrogen fertilizer levels in plant height and number of green leaves/plant at70, 90 and 110 days after transplanting (DAT) in both seasons. It is clear that the highest level of N significantly increased plant height and number of green leaves/plant as compared with control plants (100 kg/ha). The increase in plant height and number of leaves/plant with the addition of nitrogen may be attributed to more availability of nutrients, especially N, which enhances the number of leaves by its simulative effect on cell division and cell enlargement that in turn may increase number of leaves and leaf dimensions. Similar findings were reported by (Tiwori *et al*., 2002).

Sulphur fertilization significantly affected plant height and number of green leaves/plant. Increasing sulphur levels increased these parameters without significant difference between 50 and 100 kg S/ha in most cases. Moreover, the lowest values for these variables were recorded under sulphur regime of 0 kg S/ha (control).

The interaction between nitrogen and sulphur fertilizers had a significant effect on plant height at 90 DAT and number of leaves/plant at 110 DAT in 2006 season (Tables 4 and 5) . These data indicated that the lowest plant height was produced at 100 kg N/ha x 0 kg S/ha, see Table (4). Data presented in Table (5) show clearly that the highest number of leaves/plant was obtained by the combination between 200 kg N/ha and 50 kg S/ha. These results are in conformity with those found by (Gawish, 1997) who indicated that increasing the S-level to onion plants significantly increased plant height and number of green leaves.

2. Plant weight and bulb weight (gm)

Data shown in Tables (6 and 7) reveal that plant weight and bulb weight were significantly increased with increasing nitrogen fertilization at the periods 70, 90 and 110 days after transplanting. The highest weights of plant and bulb were obtained in case of using the highest rate of nitrogen level. It can be concluded that

nitrogen is an essential element for onion growth to build up protoplasm and proteins, which induce cell division and meristematic activity, resulting consequently in more plant cells in number and size with an overall increase in bulb fresh weight and plant growth (Devlin, 1979). These results are in agreement with those recorded by (Hayashi *et al*., 2003; Lee-Jongatae *et al.,* 2003).

Results showed also that plant weight of onion plants was significantly increased with increasing the levels of sulphur when compared with the control at 90 and 110 days after transplanting as well as bulb weight at 110 days after transplanting in the first season without significant differences with 50 and 100 kg S/ha. These results might be attributed to the favorable effect of sulphur on reducing soil pH, increasing soil particles flocculation, thereby improving soil structure and increasing the availability of certain plant nutrients in the soil (El-Galla *et al*., 1989). Another possibility could be due either to the fact that sulphur is required with greater supplies for onion than other crops (Schultz *et al.,*1966) or for the synthesis of coenzyme A and amino acid for protein elaboration and for the formation of certain disulphide linkages that have been associated with structural characteristics of plant protoplasm (Marschner, 1998).

The interaction among the two experimental factors under study on plant and bulb weight was not significant as shown in Tables (6 and 7). Similar results were reported by Coolong *et al*. (2004).

B. Yield and Its Components

Data concerning yield and its components, expressed as total yield, marketable yield and culls yield as well as total soluble solids (TSS%) are presented in Table (8). Application of nitrogen fertilizer had a significant effect on these traits after the curing process. The highest total yield, i.e. 13.90 and 12.02 t/ha was obtained from the treatment which received 200 kg N/ha in the first and second seasons, respectively. Moreover, increasing N-fertilizer level from 100 to 200 kg N/ha resulted in increasing marketable yield and culls yield. This might be due to applying nitrogen improving the vegetative growth and accelerating the photosythates in storage organs of bulbs resulting in an increased diameter and weight of the bulb (Sharma, 1992). These results are in agreement with those of (Patel *et al.*, 1992; Yadav *et al.,* 2005; Vetayasuporn, 2006).

Concerning the effect of sulphur fertilizer, data showed that application at 100 kg S/ha achieved the highest total yield, i.e., 13.91 and 11.07 t/ha as well as marketable yield of bulb (11.81 and 8.43 t/ha) in the first and second seasons, respectively. Also, applying 100 kg S/ha produced the highest values of culls yield (2.13 and 2.63 t/ha) and TSS % (14.37 and 14.49%) in both seasons, respectively. The influence of S on the yield of onion could be attributed to an important role of sulphur in plant protein and some hormones formation, also sulphur is necessary for enzymatic action, chlorophyll formation, synthesis of certain amino acids and vitamins, hence it helps have a good vegetative growth leading to get high yield (Tisdale and Nelson, 1985; El-Shafie and El-Gamaily, 2002). Also, Singh *et al.* (1997) showed that onion that received S up to 40 kg S/ha achieved the highest mean values of yield.

C. Characteristics of Bulb

Results in Table (9) showed that the marketable, doubles' and bolters' bulbs were significantly increased with increasing nitrogen fertilizer; whereas the highest percentage of pickles bulbs was obtained with the lowest nitrogen level (100 kg N/ha) in both seasons. This increase may be due to the stimulation effect of nitrogen on building up new cells and increasing the synthesized compounds.

Also, data in Table (9) showed that the application of sulphur gave significantly highest percentages of

marketable, doubles' and bolters' bulbs; while the lowest sulphur level (0 kg S/ha) gave the highest percentage of pickles' bulbs in both seasons.

Regarding the interaction (Table 10), the highest percentage of the doubles' bulbs was obtained from plants fertilized with the highest level of nitrogen (200 kg N/ha.) in all treatments of sulphur (0, 50 and 100 kg S/ha) during the two seasons of 2004/2005 and 2005/2006.

Under the prevailing conditions of this experiment, application of 200 kg N and 100 kg S/ha is advisable for high yield and good quality of onion bulbs in Giza 20 cultivar.

Table(1): Chemical analysis of the experimental soil at a depth of (0-30 cm), in 2004/2005 and 2005/2006 seasons.

Chemical analysis	Season	
	2004/2005	2005/2006
pH	7.6	7.5
EC (dSm^{-1})	5.58	5.41
Total nitrogen %	0.073	0.062
Available P ppm	55.9	38.2
Available K ppm	356.5	214.5
Available Fe ppm	2.004	1.948
Available Zn ppm	2.0316	1.387
Available Cu ppm	1.556	1.324
Available Mn ppm	1.332	1.104

Table(2): Plant height of onion cv. Giza 20 after 70, 90 and 110 DAT as affected by nitrogen and sulphur rates during 2004/2005 (I) and 2005/2006 (II) seasons.

Treatments	Plant height (cm)					
	At 70 days		At 90 days		At 110 days	
	I	II	I	II	I	II
Nitrogen level (kg N/ha) (A):						
100	42.08 b	39.75 c	48.92 c	44.33 b	56.17 c	52.25 c
150	43.83 b	41.75 b	50.08 b	48.50 a	59.50 b	57.00 b
200	45.17 a	43.08 a	53.42	48.33 a	61.25 a	61.00 a
F-test	**	**	**	**	**	**
Sulphur level (kg S/ha) (B):						
0	43.25	41.00 b	50.75	43.58 b	59.17	56.92
50	43.92	41.25 ab	50.33	49.00 a	58.50	56.25
100	43.92	42.33 a	51.33	48.58 ab	59.25	57.08
F-test	N.S.	*	N.S.	*	N.S.	N.S.
Interaction: A x B	N.S.	N.S.	N.S.	*	N.S.	N.S.

*, ** and N.S. indicate $P < 0.05$, $P < 0.01$ and not significant, respectively. Means of each factor designated by the same letter are not significantly different at 5% level, using Duncan's multiple range test.

Table (3): Number of green leaves/plant of onion cv. Giza 20 after 70, 90 and 110 DAT as affected by nitrogen and sulphur levels during 2004/2005 (I) and 2005/2006 (II) seasons.

Treatments	Number of green leaves/plant					
	At 70 days		At 90 days		At 110 days	
	I	II	I	II	I	II
Nitrogen level (kg N/ha) (A):						
100	5.15 c	5.13 b	5.64 c	5.86	9.48 c	9.25 c
150	5.30 b	5.25 b	6.01 b	6.06	9.95 b	9.72 b
200	5.50 a	5.49 a	6.61 a	6.68	10.43 a	10.16 a
F-test	*	*	*	N.S	*	**
Sulphur level (kg S/ha) (B):						
0	5.19	5.24	5.83 b	5.95 b	9.92	9.62
50	5.35	5.31	6.16 a	6.13 a	9.78	9.60
100	5.41	5.32	6.27 a	6.51 a	10.16	9.91
F-test	N.S.	N.S.	*	*	N.S.	N.S.
Interaction: A x B	N.S.	N.S.	N.S.	N.S.	N.S.	*

*, ** and N.S. indicate $P < 0.05$, $P < 0.01$ and not significant, respectively. Means of each factor designated by the same letter are not significantly different at 5% level, using Duncan's multiple range test.

Table (4): Plant height (cm) of onion cv. Giza 20 after 90 DAT as influenced by the interaction between nitrogen and sulphur levels in 2005/2006 season.

Sulphur level	Nitrogen level (kg N/ha)		
(kg S/ha)	100	150	200
0	33.50 b	48.25 a	49.00 a
50	51.00 a	48.25 a	47.75 a
100	48.50 a	49.00 a	48.25 a

Means designated by the same letter are not significantly different at 5% level, using Duncan's multiple range test.

Table(5): Number of green leaves/plant of onion cv. Giza 20 after 110 DAT as influenced by the interaction between nitrogen and sulphur levels in 2005/2006 season.

Sulphur level	Nitrogen level (kg N/ha)		
(kg S/ha)	**100**	**150**	**200**
0	9.40 c	9.83 abc	9.63 c
50	8.70 d	9.63 c	10.48 a
100	9.65 c	9.70 bc	10.38 ab

Means designated by the same letter are not significantly different at 5% level, using Duncan's multiple range test.

Table(6): Plant weight of onion cv. Giza 20 after 70, 90 and 110 DAT as affected by nitrogen and sulphur levels during 2004/2005 (I) and 2005/2006 (II) seasons.

	Plant weight (gm)					
Treatments	**At 70 days**		**At 90 days**		**At 110 days**	
	I	**II**	**I**	**II**	**I**	**II**
Nitrogen level (kg N/ha) (A):						
100	50.25 c	49.50 c	56.17 c	53.50 c	61.42 c	60.00 c
150	52.33 b	50.67 b	61.33 b	59.25 b	66.75 b	65.17 b
200	57.58 a	55.92 a	65.75 a	62.67 a	73.92 a	67.33 a
F-test	*	**	**	**	**	**
Sulphur level (kg S/ha) (B):						
0	52.25	51.17	59.33 b	57.58	65.67 b	64.00
50	53.75	51.58	61.33 ab	58.25	67.42 ab	63.67
100	54.17	53.33	62.58 a	59.58	69.00 a	64.83
F-test	N.S.	N.S.	*	N.S.	*	N.S.
Interaction: A x B	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

*, ** and N.S. indicate P < 0.05, P < 0.01 and not significant, respectively. Means of each factor designated by the same letter are not significantly different at 5% level, using Duncan's multiple range test.

Table(7): Bulb weight of onion cv. Giza 20 after 70, 90 and 110 DAT as affected by nitrogen and sulphur levels during 2004/2005 (I) and 2005/2006 (II) seasons.

	Bulb weight (gm)					
Treatments	**At 70 days**		**At 90 days**		**At 110 days**	
	I	**II**	**I**	**II**	**I**	**II**
Nitrogen level (kg N/ha) (A):						
100	20.92 c	20.42 c	31.17	29.83 b	40.08 b	38.67 c
150	23.83 b	23.33 b	33.25	33.50 a	42.33 ab	41.00 b
200	26.17 a	25.50 a	35.25	33.75 a	43.58 a	43.75 a
F-test	*	*	N.S	*	*	*
Sulphur level (kg S/ha) (B):						
0	23.25	22.33	33.42	32.00	40.00 b	40.08
50	23.67	23.00	33.42	32.83	42.42 ab	41.33
100	24.00	23.92	32.83	32.25	43.58 a	42.00
F-test	N.S.	N.S.	N.S.	N.S.	*	N.S.
Interaction: A x B	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

*, ** and N.S. indicate P < 0.05, P < 0.01 and not significant, respectively. Means of each factor designated by the same letter are not significantly different at 5% level, using Duncan's multiple range test.

Table(8): Total yield and its components as well as T.S.S. % of onion cv. Giza 20 as ffected by nitrogen and sulphur levels during 2004/2005 (I) and 2005/2006 (II) seasons.

Treatments	Total yield (ton/ha.)		Marketable yield (ton/ha.)		Culls yield (ton/ha.)		T.S.S. %	
	I	II	I	II	I	II	I	II
Nitrogen level (kg N/ha) (A):								
100	9.75 c	7.14 c	8.33 b	5.61 c	1.48 b	1.52 c	13.75 c	13.90 c
150	11.37 b	9.11 b	9.30 b	6.93 b	2.09 ab	2.18 b	14.03 b	14.20 b
200	13.90 a	12.02 a	11.31 a	8.92 a	2.59 a	3.10 a	14.70 a	15.07 a
F-test	**	*	**	**	**	**	**	*
Sulphur level (kg S/ha) (B):								
0	9.45 c	7.44 c	7.32 c	6.08 b	2.13	1.36 b	14.00 b	14.10 b
50	11.66 b	9.76 b	9.82 b	6.95 b	1.90	2.81 a	14.12 b	14.38ab
100	13.91 a	11.07 a	11.81 a	8.43 a	2.13	2.63 a	14.37 a	14.49 a
F-test	**	*	**	**	N.S.	**	**	*
Interaction: A x B	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

*, ** and N.S. indicate P < 0.05, P < 0.01 and not significant, respectively.Means of each factor designated by the same letter are not significantly different at 5% level, using Duncan's multiple range test.

Table(9): Percentage of marketable, doubles, bolters and pickles of onion cv. Giza 20 as affected by nitrogen and sulphur levels during 2004/2005 (I) and 2005/2006 (II) seasons.

Treatments	Marketable %		Doubles %		Bolters %		Pickles %	
	I	II	I	II	I	II	I	II
Nitrogen level (kg N/ha) (A):								
100	72.15 c	70.95 c	3.69 c	3.72 b	0.59 a	0.50	23.57 a	24.87 a
150	78.54 b	77.64 b	6.43 b	6.79 a	0.44 b	0.41	14.61 b	15.16 b
200	84.21 a	82.47 a	7.31 a	7.75 a	0.59 a	0.47	7.89 c	9.31 c
F-test	**	**	**	**	**	N.S	**	**
Sulphur level (kg S/ha) (B):								
0	75.88 c	74.80 c	5.19 b	5.42 b	0.51	0.35 b	18.42 a	19.43 a
50	78.46 b	77.34 b	6.11 a	6.21 a	0.57	0.35 b	14.86 b	16.09 b
100	80.56 a	79.06 a	6.13 a	6.63 a	0.54	0.49 a	12.80 b	13.82 c
F-test	**	**	*	*	N.S.	*	**	**
Interaction: A x B	N.S.	N.S.	**	*	N.S.	N.S.	N.S.	N.S.

*, ** and N.S. indicate P < 0.05, P < 0.01 and not significant, respectively. Means of each factor designated by the same letter are not significantly different at 5% level, using Duncan's multiple range test.

Table(10): Percentage of doubles of onion cv. Giza 20 as influenced by the interaction between nitrogen and sulphur levels in 2004/2005 and 2005/2006 seasons .

Sulphur level (kg S/ha)	Nitrogen level (kg N/ha)		
	100	**150**	**200**
		2004/2005	
0	2.88 d	5.11 b	7.58 a
50	4.60 bc	6.53 a	7.19 a
100	3.58 cd	7.67 a	7.15 a
		2006/2007	
0	2.77 d	5.53 b	7.98 a
50	4.30 bc	6.88 a	7.45 a
100	4.11 c	7.98 a	7.81 a

Means designated by the same letter are not significantly different at 5% level, using Duncan's multiple range test.

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تأثير مستويات مختلفة من التسميد النيتروجيني و الكبريتي على نمو ومحصول وجودة البصل

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ملخـص

أجريت تجربتان حقليتان بمزرعة في ـ غور الصافي ـ الأردن خلال موسمي 2005/2004 م و2006/2005 م لدراسة تأثير إضافة ثلاثة مستويات من التسميد النيتروجيني (100، 150، 200 كجم نيتروجين/هكتار) وثلاثة مستويات من التسميد الكبريتي (صفر، 50، 100 كجم كبريت/هكتار) على النمو والمحصول وجودة البصل في صنف البصل جيزة 20. وتضمنت أهم النتائج ان زيادة التسميد النيتروجيني والكبريتي أدت إلى زيادة معنوية في ارتفاع النبات وعدد الأوراق للنبات ووزن الأوراق والأبصال عند مراحل النمو المختلفة للبصل فى كلا الموسمين.

كما أدت زيادة مستوى التسميد النيتروجيني إلى 200 كجم نيتروجين/هكتار والكبريتي من صفر إلى 100 كجم كبريت/هكتار إلى زيادة معنوية في المحصول الكلي والقابل للتسويق والنقضة ونسبة الأبصال القابلة للتسويق والمزدوجة والحنبوط والمواد الصلبة الذائبة. كما أظهرت الدراسة أيضا أن أقل نسبة من محصول البصيلات تم الحصول عليها بزيادة مستوى التسميد النيتروجيني والكبريتي بالموسمين.

وعموما يمكن توصية مزارعي البصل من صنف جيزة 20 للحصول على أعلى محصول صالح للتسويق ومحصول كلي ذي جودة عالية بالتسميد النيتروجيني بمعدل 200 كجم نيتروجين/هكتار مع التسميد بمعدل 100 كجم كبريت/هكتار في ظروف مشابهة للظروف التي أجري فيها هذا البحث.

الكلمات الدالة: بصل، نيتروجين، كبريت، المجموع الخضري، إنتاجية البصل، وزن النبات.

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