Emir. J. Agric. Sci. (1992) 4: 27-51

Growth and Assimilation Performance in Garlic in Relation to Grown Cultivar and Nitrogen Fertilization.

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ABSTRACT :

The effect of N-level along with its frequency of application on growth and assimilation performance in Egyptian, Chinese and American garlic cultivars was studied. Rates of relative growth, net assimilation and economic assimilation as well as harvest index were considered as indices to growth and assimilation performance in plants.

At the early growth period, Egyptian cultivar achieved the highest record in both relative growth and net assimilation rates. Whereas, the Chinese cultivar showed superiority in economic assimilation rate at all tested growth periods. It could also be considered as a high yielding genotype, as it was characterized by the highest harvest index, followed by the American and Egyptian cultivars.

The effect of applied N-level on both rates of relative growth and net assimilation seemed to vary according to growth period. Besides, increasing N-level of application led to increasing economic assimilation rate.

Splitting N in two equal doses was more effective in increasing relative growth rate compared to splitting in three equal doses. The two doses splitting of nitrogen also proved to be of higher effect on both economic and net assimilation rates.

Key words : Garlic, growth, Nitrogen, fertilization, assimilation, and yield.

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INTRODUCTION

As no flowering could be obtained from garlic plants, it becomes difficult for breeders to put hands on new genotypes and consequently importation and evaluation of new garlic cultivars are very active and quick methods in garlic improvement.

Nitrogen is the nutrient that proved to have the greatest effect on garlic plant growth and metabolism and consequently on bulbing. It thus; was reported to improve bulb weight, diameter and dry matter percent in Egyptian cultivar of garlic. Nitrogen also increased fresh and dry weights in leaves of the Chinese garlic cultivars., whereas no significant variation in bulbing ratio was observed (Maksoud et al., 1984 a). Much of the success in garlic growing lies in supplying nitrogen at the right time. Therefore, N was more beneficial when added to garlic within two periods, 60 and 90 days from planting (Ismail et al, 1980).

The aim of this study is to determine the fittest N-dose, along with its right time of application, for three garlic cultivars in relation to plant growth and assimilation performance.

MATERIALS AND METHODS

Two field experiments were conducted to study the response of three garlic cultivars, i.e. Egyptian, Chinese and American to N-fertilizer levels, i.e. 0, 30, 60 and 90 kg N/feddan (feddan = 4200 m^2), and its frequency of application, i.e. splitting in two or three equal doses. The design of the experiments was split split-plot with four replicates where cultivars, N-levels and number of N-fertilizer doses were arranged as main, sub and sub-sub plots, respectively.

The tested nitrogen levels were equally splitted in two, i.e. 30 and 60 days from planting, or three, i.e. 30, 60 and 90 days from planting doses. Ammonium sulphate (20.50% N) was used as a source of nitrogen.

Seed bulbs and their included cloves were selected for uniformity in shape and size, and planting took place on October, 5th and 8th in 1984 and 1985 seasons, respectively. The normal practices of growing garlic were adopted.

During the growth period, three plant samples were obtained at 20 day intervals beginning 90 days from planting. Each plant sample consisted of 10 guarded plants taken from the two inner rows. The following data were recorded using the plant samples:

1. Relative growth rate (RGR) :

$$RGR = \frac{\ln W_1 - \ln W_0}{T_1 - T_0} \text{ (mg/gm/day)} \quad \text{-(Richards, 1969).}$$

Where : W_1 and W_0 are the plant dry weights at T_1 and T_0, respectively, but T_1 and T_0 are the times of sampling.

2. Net assimilation rate (NAR) :

$$NAR = \frac{W_2 - W_1}{L_2 - L_1} \times \frac{\text{Log } L_2 - \text{Log } L_1}{t_2 - t_1} \text{ (mg/cm}^2\text{/day)} \quad -$$

(McCollum, 1978).

Where : W_1 and W_2 are dry weights of plants at t_1 and t_2, L_1 and L_2 are leaf area at t_1 and t_2, but t_1 and t_2 are time of sampling.

3. Economic assimilation rate (EAR) :

EAR = D. Wt bulb / dt X 1/L (mg D.Wt in bulb/ cm2/day)

(Harper, 1963)

Where : D.Wt bulb = dry weight of bulb, L = leaf area, and t = time. EAR is, thus, analagous to NAR as used traditionally, but changes in product dry matter, rather than in total plant weight over a time interval, "dt" are used in its calculation.

4. Harvest index (HI) :

The harvest index was used as a migration coefficient (Singh and Stockopf, 1971).

$$HI = \frac{\text{Bulb dry weight [Economic yield]}}{\text{Whole plant dry weight [biological yield]}} \times 100$$

(Coombs and Hall, 1982).

Data were subjected to proper statistical analysis according to Snedecor and Cochran, (1967). The data expressed as percentages were transformed to are sine values prior to the statistical analysis. Soil physical and chemical analysis was done (Table 1).

RESULTS AND DISCUSSION

1. Relative growth rate (RGR) and Net assimilation rate (NAR) :

1.1 Effect of cultivar :

Significant variations in relative growth rate and net assimilation rate were noticed due to grown cultivar (Tables 2 and 3).

However, the variability among cultivars in the above mentioned growth indices seems to be dependent on growth period.

At 90 - 110 days plant age, the Egyptian cultivar achieved the highest record in both relative growth and net assimilation rates, followed by the american and then the Chinese cultivars.

At more advanced growth period, i.e. 110 - 130 days from planting, the American cultivar insignificantly exceeded the Egyptian with regards to both relative growth and net assimilation rates, whereas the Chinese cultivar came later in this connection. This result may be interpreted on the basis that the American cultivar proved, as shown from the field observations, to be of lated growth and maturity as

Table 1. Soil physical and chemical analysis (Depth 0-40 cm).

Particles fractions %				
Coarse sand	Fine sand	Silt	Clay	texture grade
2.10	17.33	51.70	28.87	Silty clay loam

pH 1:2.5– water:soil suspension	E.C.* (m mohs/ cm)	C.E.C.** (meg/100g soil)	Soluble ions in soil paste extract (meg/110 g soil).						
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
7.9	1.0	31.6	10.9	8.8	4.2	0.8	7.6	6.0	11.4

* Electric conductivity
** Cation exchange capacity

Nutrient status on soil (ppm)						
in soil extract			in 1:2 Soil-DTPA extract			B
N	P	K	Fe	Mn	Zn	
120	27	45	0.65	1.45	0.76	0.81

compared to the other tested cultivars. Maksoud et al. (1983 a) came to the same conclusion.

It worths mentioning that both rates of growth and net assimilation appeared to be higher when assessed at the earlier growth period. Results may be explained again on the basis that the photosynthetic efficiency was higher during the early stages of plant growth.

1.2 Effect of nitrogen level :

The effect of applied nitrogen level on both relative growth and net assimilation rates seemed to vary according to growth period. At the early period of growth, i.e. 90 - 110 days from planting, both growth and assimilation rates were decreased due to increases of nitrogen level, so the check plants achieved the highest records. At more advanced growth period, i.e. 110 - 130 days from planting, the opposite was true (Tables 2 and 3).

Results could be explained on the basis that nitrogen supplies affect growth and assimilation rates in plant mainly by altering the size of the photosynthetic apparatus (leaf area) and it may also affect leaf efficiency (McCollum, 1978). The enhancement effect of N was observed to be delayed in the season giving opportunity for growing plants to assimilate the absorbed nutrients. Similar increase in NAR was observed by Dyson and Watson (1971) due to N application in potato.

1.3 Effect of N-frequency of application :

As it can be seen from data in Tables (2 and 3), the two equal doses application of nitrogen was generally more effective for both growth and net assimilation increase rates as compared to the three ones. This result was true for both the periods of 90 - 110 or 110 - 130 days from planting.

Results could be interpreted as the two equal doses application of nitrogen gave the opportunity for adding the total fertilizer dose at earlier and more active growth period, thereby ensuring favourable nutritional status for growth and assimilation in plant.

Table 2 A. Effect of nitrogen fertilizer, level and frequency of application, on relative growth rate (RGR : gm/gm/day) of three garlic cultivars at the period of 90 - 110 days from planting.

N-frequency of application	Two doses				Three doses				Average				
N-Level Kg/ N-fed / Cultivars	Check	30	60	90	mean	30	60	90	mean	check	30	60	90	mean
						90 - 110 days from planting								
						- 1984 -								
Egyptian	0.0070	0.0120	0.0120	0.0120	0.0123	0.0060	0.0090	0.0130	0.0093	0.0070	0.0090	0.0110	0.0130	0.0100
Chinese	0.0100	0.0070	0.0040	0.0030	0.0060	0.0050	0.0040	0.0020	0.0037	0.0100	0.0060	0.0040	0.0030	0.0058
American	0.0140	0.0160	0.0050	0.0050	0.0087	0.0100	0.0020	0.0050	0.0057	0.0140	0.0130	0.0040	0.0050	0.0090
Mean	0.0103	0.0116	0.0073	0.0067	0.0086	0.0070	0.0050	0.0067	0.0062	0.0103	0.0093	0.0063	0.0070	

L.S.D. (P = 0.05) : Cultivar (A) = 0.0007 N-Level (B) = 0.0007
N-frequency of appl. (C) = 0.0006 A x B = 0.0013 A x C = N.S. B x C = 0.0013 A x B x C = N.S

- 1985 -

Egyptian	0.0008	0.0120	0.0140	0.0140	0.0133	0.0070	0.0100	0.0130	0.0100	0.0080	0.0100	0.0120	0.0140	0.0110
Chinese	0.0100	0.0080	0.0040	0.0030	0.0050	0.0040	0.0030	0.0020	0.0030	0.0100	0.0060	0.0040	0.0030	0.0090
American	0.0140	0.0160	0.0040	0.0060	0.0087	0.0090	0.0030	0.0050	0.0057	0.0140	0.0130	0.0040	0.0060	0.0090
Mean	0.0107	0.012	0.073	0.077	0.0090	0.0067	0.0053	0.0067	0.0062	0.0107	0.0097	0.0067	0.0077	

L.S.D. (P = 0.05) : Cultivar (A) = 0.0006 N-Level (B) = 0.0006
N-frequency of appl. (C) = 0.0006 A x B = 0.0010 A x C = N.S B x C = 0.0011 A x B x C = N.S.

Table 2 B. Effect of nitrogen fertilizer, level and frequency of application, on relative growth rate (RGR : gm/gm/day) of three garlic cultivars at the period of 110 - 130 days from planting.

N-frequency of application	Two doses					Three doses				Average				
N-Level Kg/ N-fed	Check	30	60	90	mean	30	60	90	mean	check	30	60	90	mean
Cultivars														
110 - 130 days from planting														
- 1984 -														
Egyptian	0.0077	0.0085	0.0076	0.0094	0.0085	0.0072	0.0047	0.0058	0.0059	0.0077	0.0079	0.0062	0.0076	0.0074
Chinese	0.0002	0.0074	0.0029	0.0049	0.0031	0.0090	0.0034	0.0013	0.0014	0.0002	0.0082	0.0032	0.0018	0.0009
American	0.0036	0.0091	0.0181	0.0165	0.01460.0056		0.0144	0.0157	0.0119	0.0036	0.0074	0.0163	0.0161	0.0109
Mean -	0.0038	0.0083	0.0076	0.0103	0.0087	0.0073	0.0052	0.0067	0.0064	0.0038	0.0078	0.0064	0.0073	
L.S.D. (P = 0.05) : Cultivar (A) = 0.0001 N-Level (B) = 0.0001														
N-frequency of appl. (C) = 0.0001 A x B = 0.0002 A x C = 0.0002 B x C = 0.0002 A x B x C = 0.0004														
- 1985 -														
Egyptian	0.0106	0.0112	0.0072	0.0085	0.0090	0.0094	0.0058	0.0047	0.0066	0.0106	0.0103	0.0065	0.0066	0.0085
Chinese	0.0025	0.0044	0.0004	0.0018	0.0036	0.0070	0.0011	0.0009	0.0023	0.0025	0.0082	0.0008	0.0014	0.0029
American	0.0008	0.0085	0.0135	0.0150	0.0123	0.0076	0.0110	0.0133	0.0106	0.0008	0.0081	0.0123	0.0124	0.0084
Mean	0.0046	0.0097	0.0068	0.0084	0.0083	0.0080	0.0052	0.0063	0.0065	0.0046	0.0079	0.0060	0.0068	
L.S.D. (P = 0.05) : Cultivar (A) = 0.0002 N-Level (B) = 0.0002														
N-frequency of appl. (C) = 0.0012 A x B = 0.0003 A x C = 0.0002 B x C = 0.0024 A x B x C = 0.0004														

Table 3A. Effect of nitrogen fertilizer, level and frequency of application, on net assimilation rate (NAR mg/cm^2/day) of three garlic cultivars at the period of 90 - 110 days from planting.

N-frequency of application	Two doses				Three doses				Average				
N-Level Kg/ N-fed / Cultivars	Check	30	60	90	mean	30	60	90	mean	check	30	60	90	mean
						90 - 110 days from planting								
						- 1984 -								
Egyptian	0.36	0.28	0.36	0.33	0.32	0.15	0.26	0.36	0.26	0.36	0.22	0.31	0.35	0.31
Chinese	0.28	0.23	0.13	0.08	0.15	0.12	0.13	0.07	0.11	0.28	0.18	0.10	0.08	0.16
American	0.40	0.48	0.15	0.14	0.26	0.30	0.12	0.13	0.18	0.40	0.39	0.14	0.14	0.27
Mean	0.35	0.33	0.21	0.18	0.24	0.19	0.17	0.18	0.35	0.34	0.26	0.18	0.19	
L.S.D. (P = 0.05) : Cultivar (A) = 0.0007			N-Level (B) = 0.012											
N-frequency of appl. (C) = 0.009		A x B = 0.02			A x C = N.S.		B x C = 0.08		A x B x C = 0.031					
						- 1985 -								
Egyptian	0.34	0.30	0.35	0.34	0.33	0.17	0.28	0.37	0.27	0.34	0.24	0.32	0.36	0.32
Chinese	0.29	0.24	0.14	0.10	0.16	0.13	0.11	0.09	0.11	0.29	0.19	0.13	0.10	0.18
American	0.38	0.46	0.18	0.16	0.27	0.31	0.14	0.13	0.19	0.38	0.39	0.16	0.15	0.27
Mean	0.34	0.33	0.22	0.20	0.25	0.20	0.18	0.20	0.19	0.34	0.27	0.20	0.20	
L.S.D. (P = 0.05) : Cultivar (A) = 0.0003			N-Level (B) = 0.009											
N-frequency of appl. (C) = 0.01		A x B = 0.016			A x C = N.S.		B x C = 0.02		A x B x C = 0.034					

Table 3B. Effect of nitrogen fertilizer, level and frequency of application, on net assimilation rate (NAR mg/cm^2/day) of three garlic cultivars at the period of 110 - 130 days from planting.

N-frequency of application		Two doses				Three doses				Average				
N-Level Kg/ N-fed / Cultivars	Check	30	60	90	mean	30	60	90	mean	check	30	60	90	mean
110 - 130 days from planting														
- 1984 -														
Egyptian	0.33	0.29	0.19	0.39	0.29	0.25	0.18	0.18	0.20	0.33	0.277	0.19	0.29	0.27
Chinese	0.01	0.36	0.16	0.23	0.14	0.14	0.16	0.06	0.06	0.01	0.39	0.16	0.09	0.11
American	0.17	0.46	0.89	0.72	0.69	0.25	0.61	0.69	0.52	0.17	0.36	0.75	0.71	0.50
Mean	0.17	0.37	0.31	0.45	0.37	0.30	0.21	0.27	0.26	0.17	0.34	0.26	0.36	
L.S.D. (P = 0.05) : Cultivar (A) = 0.011				N-Level (B) = 0.011										
N-frequency of appl. (C) = 0.009			A x B = 0.020		A x C = 0.016			B x C = 0.018		A x B x C = 0.032				
- 1985 -														
Egyptian	0.45	0.41	0.30	0.36	0.36	0.34	0.25	0.19	0.26	0.45	0.38	0.28	0.28	0.35
Chinese	0.12	0.52	0.02	0.10	0.20	0.35	0.06	0.05	0.11	0.12	0.44	0.04	0.08	0.15
American	0.01	0.53	0.83	0.84	0.73	0.41	0.57	0.66	0.55	0.01	0.07	0.70	0.75	0.48
Mean	0.19	0.49	0.37	0.43	0.43	0.37	0.25	0.30	0.31	0.19	0.43	0.31	0.37	
L.S.D. (P = 0.05) : Cultivar (A) = 0.006				N-Level (B) = 0.01										
N-frequency of appl. (C) = 0.08			A x B = 0.017		A x C = 0.013			B x C = 0.016		A x B x C = 0.027				

1.4 The interaction's effect :

The interaction of cultivar and nitrogen level of application significantly affected relative growth rate where the American cultivar with no N-addition achieved the highest record. This result was true in the first season, whereas the Egyptian cultivar receiving 90 kg N/fedd. being higher in the second season. On the other hand, the lowest record in RGR as assessed at the period of 90 - 110 days from planting was obtained with the Chinese cultivar receiving 90 kg N/fedd. At more advanced growth stage, i.e. 110 - 130 days from planting, the Chinese cultivar receiving no N in 1984 or 60 kg N/fedd. in 1985 had lower RGR.

The interaction of cultivar and N-level significantly affected NAR. At the earlier growth period, i.e. 90 - 110 days from planting, the American cultivar with no N-addition gave the highest NAR, whereas the lowest record was obtained with the Chinese cultivar receiving 90 kg N/feddan. At more advanced growth stage, i.e. 110 - 130 days from planting, the highest value of NAR was obtained with the American cultivar when 60 and 90 kg N/fedd. were applied in 1984 and 1985 seasons respectively. At the above mentioned growth period the Chinese cultivar receiving 60 kg N/fedd. gave the lowest value of NAR in both seasons.

The interaction between grown cultivar and time of N application exerted no significant variation in either relative growth or net assimilation rates when assessed at 90 - 110 days plant age. At more advanced growth stage, i.e. 110 - 130 days from planting, the American cultivar receiving the two equal doses of nitrogenous fertilizer significantly had the highest RGR and NAR values, whereas the Chinese cultivar receiving the three equal doses of nitrogen was of the lowest records.

Regarding the interaction of N-level and its frequency of application, data show that the two equal doses application of 30 kg N/fedd. gave the highest RGR as assessed at the period of 90 - 110 days from planting. At more advanced growth period, i.e. 110 - 130 days from planting, the addition of two equal doses of 90 kg N/fedd. in 1984 and 30 kg N/fedd. in 1985 proved to be more beneficial in this connection.

However, data in Tables (2 and 3) indicated that plants receiving no N addition gave the highest NAR, whereas those receiving 60 kg N/fedd. as three equal doses had the lowest records. These results are true when NAR was assessed at the period of 90 - 110 days from planting. At more advanced growth stage, i.e. 110 - 130 days from planting, the two equal doses application of 90 or 30 kg N/fedd. resulted in the highest values of NAR in 1984 and 1985 seasons, respectively. At the above mentioned period, the lowest NAR was obtained in plants receiving 60 kg N/fedd. splitted in three equal doses.

Concerning the three-factors (cultivar, N-level and frequency of N application) interaction effect, it resulted in significant variation in RGR at the latest growth period only where the highest record was obtained with the American cultivar receiving two equal doses of 60 and 90 kg N/fedd. in the first and second seasons, respectively. In this connection, the lowest RGR was noticed with the Chinese cultivar receiving 60 kg N/fedd. splitted in three equal doses.

Also, the three factors-interaction effect caused significant variation in NAR at both studied growth period. At the early growth period, the American cultivar achieved the highest NAR when the plants received two equal doses of 30 kg N/fedd. At the latest growth period, the American cultivar receiving two equal doses of 60 and 90 kg N/fedd. in 1984 and 1985 seasons, respectively, achieved the highest NAR. At this stage, the lowest NAR was obtained with the Chinese cultivar receiving three equal doses of 60 kg N/fedd.

2. Economic assimilation rate (EAR) :

Quantitative estimates of EAR should be a useful adjunct to NAR in optimizing plant populations and planting patterns, studying effect of differing nutritional regimes on growth and yield, and in comparing relative efficiencies of species or varieties as partitioners of biological energy.

2.1 Effect of cultivar :

Economic assimilation rate seems to be increased with plant age, as the highest values were obtained at 130 days from planting. This result was true with all tested cultivars

and possibly could be due to the reduction in the formation of new vegetative growth at the latened growth stages, thereby increasing the migration of metabolites towards bulb as storage organ. Improving economic assimilation rate as previously defined is thus quite expected.

A varietal variation in the economic assimilation rate could also be observed from data in Table (4), the highest record was obtained, with slight discrepancies, with the Chinese cultivar. This result was true at all tested growth periods. At the earlier period, i.e. 90 days from planting, the Chinese cultivar was followed by the Egyptian and the American cvs. At the latened periods, i.e. 110 and 130 days from planting, the American cultivar exceeded that of the Egyptian one.

Results may be explained to be due to the variation in the relative efficiencies of the varieties as partitioners of biological energy. This drawn suggestion was previously discussed by McCollum (1978).

The superiority of the Chinese cultivar in EAR, particularly at the earlier growth period, was consistent with field observation as this cultivar always showed earlier bulbing compared to the other tested cultivars. So, the earlier bulbing is logical to be followed by increased accumulation of dry matter in bulbs. The Chinese cultivar was also reported by Maksoud et al. (1983 a and 1984 b) to be earlier in bulbing comparing to the Egyptian and the American cultivars.

2.2 Effect of nitrogen level :

Increasing the nitrogen level of application led to increased economic assimilation rates of the plants (Table 4). The 90 kg N/fedd. dose gave the highest EAR values as assessed at 90 days plant age. The 60 kg N/fedd. dose proved to be more effective at more advanced growth stages, i.e. 110 and 130 days from planting.

Nitrogen supplies increased dry matter accumulation in storage organ of garlic by improving both photosynthetic apparatus (leaf area), leaf efficiency, and net assimilation rate, and thus enhanced EAR is quite expected.

Table 4 A : Effect of nitrogen fertilizer, level and frequency of application, on economic assimilation rate (EAR : mg D. wt bulb / cm^2 / day) of three garlic cultivars at 90 days from planting.

N-frequency of application	Two doses					Three doses				Average				
N-Level Kg/ N/fed Cultivars	Check	30	60	90	mean	30	60	90	mean	check	30	60	90	mean
						90 days from planting								
						- 1984 -								
Egyptian	0.068	0.066	0.061	0.066	0.064	0.066	0.060	0.066	0.064	0.068	0.066	0.061	0.066	0.065
Chinese	0.047	0.065	0.102	0.107	0.091	0.060	0.068	0.105	0.088	0.047	0.063	0.100	0.106	0.079
American	0.068	0.074	0.070	0.068	0.068	0.059	0.050	0.054	0.054	0.068	0.067	0.060	0.061	0.064
Mean	0.061	0.068	0.078	0.080	0.080	0.062	0.069	0.075	0.069	0.061	0.065	0.074	0.078	0.070

L.S.D. (P = 0.05) : Cultivar (A) = 0.0036 N-Level (B) = 0.0015
N-frequency of appl. (C) = 0.0039 A x B = 0.0026 A x C = 0.0031 B x C = 0.0031 A x B x C = 0.0055

						- 1985 -								
Egyptian	0.070	0.071	0.065	0.070	0.069	0.070	0.076	0.067	0.074	0.070	0.071	0.071	0.069	0.070
Chinese	0.051	0.064	0.100	0.086	0.083	0.050	0.087	0.079	0.072	0.051	0.057	0.094	0.083	0.071
American	0.050	0.063	0.048	0.074	0.062	0.053	0.046	0.058	0.052	0.050	0.058	0.047	0.066	0.055
Mean	0.057	0.066	0.071	0.077	0.071	0.058	0.070	0.068	0.065	0.057	0.062	0.071	0.073	0.066

New L.S.D. (P = 0.05) = Cultivar (A) = 0.0040 N-Level (B) = 0.0021
N-frequency of appl. (C) = 0.0037 A x B = 0.0031 A x C = 0.0340 B x C = 0.0029 A x B x C = 0.0048

Table 4 B : Effect of nitrogen fertilizer, level and frequency of application, on economic assimilation rate (EAR : mg D. wt bulb / cm^2 / day) of three garlic cultivars at 90 days from planting.

N-frequency of application	Two doses					Three doses				Average				
N-Level Kg/ N/fed Cultivars	Check	30	60	90	mean	30	60	90	mean	check	30	60	90	mean
						110 days from planting - 1984 -								
Egyptian	0.077	0.045	0.067	0.070	0.061	0.040	0.065	0.060	0.055	0.077	0.043	0.066	0.065	0.083
Chinese	0.074	0.100	0.151	0.139	0.130	0.078	0.125	0.132	0.112	0.074	0.089	0.138	0.136	0.109
American	0.077	0.103	0.103	0.082	0.096	0.085	0.083	0.071	0.080	0.077	0.094	0.093	0.077	0.085
Mean	0.076	0.083	0.107	0.097	0.096	0.068	0.091	0.088	0.082	0.076	0.075	0.099	0.093	0.086

L.S.D. (P = 0.05) : Cultivar (A) = 0.0021 N-Level (B) = 0.0022
N-frequency of appl. (C) = 0.0013 A x B = 0.0038 A x C = 0.0023 B x C = 0.0027 A x B x C = 0.0010

						- 1985 -								
Egyptian	0.082	0.045	0.064	0.073	0.061	0.040	0.066	0.061	0.056	0.082	0.043	0.065	0.067	0.064
Chinese	0.087	0.103	0.157	0.160	0.140	0.087	0.131	0.130	0.116	0.087	0.095	0.144	0.145	0.118
American	0.080	0.108	0.113	0.099	0.107	0.088	0.083	0.085	0.085	0.080	0.098	0.098	0.098	0.092
Mean	0.083	0.085	0.111	0.111	0.103	0.072	0.093	0.092	0.086	0.083	0.079	0.102	0.101	0.091

L.S.D. (P = 0.05) : Cultivar (A) = 0.0330 N.Level (B) = 0.0029
N-frequency of appl. (C) = 0.0017 A x B = 0.0400 A x C = 0.0031 A x B x C = 0.0029

Table 4 C : Effect of nitrogen fertilizer, level and frequency of application, on economic assimilation rate (EAR : mg D. wt bulb / cm^2 / day) of three garlic cultivars at 130 days from planting.

N-frequency of application	Two doses				Three doses				Average				
N-Level Kg/ N/fed Cultivars	Check	30	60	90	mean	30	60	90	mean	check	30	60	90	mean
130 days from planting - 1984 -														
Egyptian	0.144	0.175	0.210	0.227	0.204	0.195	0.197	0.199	0.197	0.144	0.185	0.204	0.213	0.187
Chinese	0.189	0.202	0.242	0.245	0.230	0.02	0.223	0.213	0.213	0.189	0.202	0.233	0.229	0.213
American	0.174	0.236	0.248	0.208	0.231	0.177	0.235	0.202	0.211	0.174	0.217	0.242	0.205	0.210
Mean	0.169	0.204	0.233	0.227	0.222	0.198	0.218	0.205	0.207	0.169	0.201	0.226	0.216	0.203

L.S.D. (P = 0.05) : Cultivar (A) = 0.0024 N-Level (B) = 0.0042
N-frequency of appl. (C) = 0.0019 A x B = 0.0049 A x C = 0.0027 B x C = 0.0027 A x B x C = 0.0030

- 1985 -														
Egyptian	0.142	0.191	0.209	0.225	0.208	0.207	0.216	0.198	0.207	0.142	0.199	0.213	0.212	0.192
Chinese	0.181	0.229	0.260	0.269	0.253	0.188	0.247	0.274	0.236	0.181	0.209	0.254	0.272	0.229
American	0.155	0.289	0.288	0.252	0.276	0.238	0.261	0.220	0.240	0.155	0.264	0.275	0.236	0.233
Mean	0.159	0.236	0.252	0.249	0.246	0.211	0.241	0.231	0.228	0.159	0.224	0.247	0.240	0.218

L.S.D. (P = 0.05) : Cultivar (A) = 0.0029 N-Level (B) = 0.0045
N-frequency of appl. (C) = 0.0050 A x C = 0.0034 B x C = 0.0032 A x B x C = 0.0041

2.3 Effect of N-frequency of application :

The two equal doses application of nitrogen was more effective for increasing EAR in garlic plants as compared to the three equal doses. This result may be interpreted as increases the number of N doses was followed by latened vegetative growth, and consequently, a reduction in the amounts of metabolites migrated towards bulb as storage organ.

2.4 The interaction's effect :

With slight discrepancies, the highest EAR record was obtained with the Chinese cultivar receiving the highest N-level of 90 kg N/fedd. (Table 4). This result was true in the first and second assessments, i.e. at 90 and 110 days plant age, whereas in the third assessment, the American cultivar receiving 60 kg N/fedd. proved to be superior.

An interactive effect between cultivar and frequency of N application could also be noticed to affect EAR. In this connection, the Chinese cultivar achieved the highest EAR when N was applied in two equal doses. This result was true at 90 and 110 days from planting, whereas at the more advanced growth period, i.e. 130 days plant age, the two equal doses application of N proved to be more effective with the American cultivar.

The positive response of the Chinese cultivar to high N-level that was noticed at the earlier growth periods could be interpreted as a characteristic of the early bulbing of this cultivar (Maksoud, et al. 1983 a and 1984 b). The migration of metabolites towards bulb begins early, and is highly reflected on EAR.

Besides the above mentioned, the Chinese cultivar seems to have an early response to the two equal doses application of N, and this could be interpreted on the same basis of earlier bulbing.

It could also be noticed from the data that the two equal doses application of the relatively high N-levels, i.e. 60 and 90kg N/fedd. depending on plant age, was more effective in EAR.

With regards to the three-factor interaction effect, it seems likely that the Chinese cultivar receiving two equal doses of the relatively high N-levels, i.e., 60 or 90 kg N/fedd., is of superior EAR as assessed at 90 or 110 days plant age, the American cultivar receiving 30 and 60 kg N/fedd. in 1984 and 1985 seasons respectively, achieved the highest EAR.

3. Harvest index (HI)

3.1 Effect of cultivar :

Based on the harvest index, the Chinese cultivar could be considered a high yielding genotype, as it was characterized by the highest harvest index (Table 5). In this connection, the cultivar was followed, with slight exceptions, by the American and then the Egyptian cultivars in a descending order. Obtained results could be explained due to the high coefficient migration in the Chinese cultivar on one hand and to its high potentiality of carbohydrate synthesis on the other hand.

3.2 Effect of nitrogen level :

The harvest index positively responded to nitrogen application (Table 5). The high doses of N were observed to be more effective on this assimilation attribute.

The favourable effect of nitrogen on harvest index is quite expected due to the key role of this nutrient in plant metabolism particularly the photosynthesis process, factor which is ultimately reflected on dry matter accumulation in plant organs.

3.3 Effect of N-frequency of application :

The two equal doses application of nitrogen had a higher effect on the harvest index in garlic plants (Table 5). The obtained results appeared to be logical since the further splitting of added fertilizer gave the opportunity for further and latened vegetative growth, thereby reducing the surplus of metabolites migration towards bulb. Similar conclusion was previously drawn by Midan et al. (1982) on onion.

Table 5 A : Effect of nitrogen fertilizer, level and frequency of application, on harvest index (HI %) of three garlic cultivars at 90 days from planting.

N-frequency of application	Two doses				Three doses				Average				
N-Level Kg/ N/fed Cultivars	Check	30	60	90	mean	30	60	90	mean	check	30	60	90	mean
						90 days from planting - 1984 -								
Egyptian	28.86	22.54	20.31	22.05	21.63	21.67	20.19	22.08	21.31	22.86	22.11	20.25	22.07	21.82
Chinese	20.94	27.16	36.39	31.48	31.68	23.20	35.01	30.63	21.61	20.94	25.18	35.70	31.06	28.22
American	19.32	23.26	24.73	23.48	23.82	16.82	17.34	19.21	17.34	19.32	20.30	21.04	21.35	20.50
Mean	21.04	24.32	27.14	25.67	25.71	20.56	24.18	23.77	22.90	21.04	22.53	25.66	24.83	

L.S.D. (P = 0.05) : Cultivar (A) = 2.41 N-Level (B) = 1.27
N-frequency of appl. (C) = 1.88 A x B = 4.26 A x C = 3.81 B x C = 3.88 A x B x C = 4.75

						- 1985 -								
Egyptian	21.18	21.09	20.32	21.18	20.86	21.59	19.48	20.43	20.50	21.18	21.34	19.90	20.81	20.81
Chinese	20.83	24.56	34.26	36.66	31.83	22.03	31.55	35.43	9.67	20.83	23.30	32.91	36.05	28.27
American	22.32	26.22	24.79	25.16	25.39	23.95	18.12	20.84	20.97	22.32	25.09	21.46	23.09	22.97
Mean	21.44	23.96	26.46	27.67	26.03	22.52	23.05	25.57	23.71	21.44	23.24	24.76	26.62	

L.S.D. (P = 0.05) : Cultivar (A) = 3.11 N-Level (B) = 2.08
N-frequency of appl. (C) = 2.14 A x B = 3.78 A x C = 4.17 B x C = 4.21 A x B x C = 4.88

Table 5 B : Effect of nitrogen fertilizer, level and frequency of application, on harvest index (HI %) of three garlic cultivars at 110 days from planting.

N-frequency of application		Two doses				Three doses				Average				
N-Level Kg/ N/fed / Cultivars	Check	30	60	90	mean	30	60	90	mean	check	30	60	90	mean
						110 days from planting - 1984 -								
Egyptian	25.90	23.04	29.20	30.76	27.67	22.16	28.26	26.78	25.73	25.90	22.60	28.73	28.77	26.60
Chinese	23.17	28.70	38.90	48.13	38.58	26.27	39.09	44.40	36.59	23.17	27.49	39.00	46.27	33.98
American	23.36	27.82	38.38	34.81	33.67	23.33	30.25	30.50	28.03	23.36	25.58	34.44	32.66	29.01
Mean	24.14	26.25	35.49	37.90	33.31	23.92	32.53	33.89	30.12	24.14	25.22	34.06	35.90	
L.S.D. (P = 0.05) : Cultivar (A) = 2.28 N-Level (B) = 3.67														
N-frequency of appl. (C) = 1.12 A x B = 4.22 A x C = 3.16 B x C = 3.87 A x B x C = 4.16														
						- 1985 -								
Egyptian	26.62	23.46	27.12	29.82	26.80	21.00	26.69	26.16	24.62	26.62	22.23	26.91	27.99	25.94
Chinese	26.68	27.45	39.03	43.55	36.68	21.59	37.89	40.92	33.47	26.68	24.52	38.46	42.24	32.98
American	24.01	27.46	29.17	28.78	28.47	25.98	25.18	27.53	26.23	24.01	26.72	27.18	28.16	26.52
Mean	25.77	26.12	31.77	34.05	30.65	22.86	29.92	31.54	28.11	25.77	24.49	30.85	32.80	
L.S.D. (P = 0.05) : Cultivar (A) = 3.07 N-Level (B) = 2.55														
N-frequency of appl. (C) = 0.97 A x B = 3.57 A x C = 2.89 B x C = 4.11 A x B x C = 4.50														

Table 5 C : Effect of nitrogen fertilizer, level and frequency of application, on harvest index (HI %) of three garlic cultivars at 130 days from planting.

N-frequency of application	Two doses				Three doses				Average				
N-Level Kg/ N/fed Cultivars	Check	30	60	90	mean	30	60	90	mean	check	30	60	90	mean
						130 days from planting - 1984 -								
Egyptian	43.30	49.45	53.36	54.86	52.52	52.69	53.63	50.66	52.33	43.30	51.07	53.45	52.76	50.15
Chinese	48.09	52.67	56.96	56.98	55.60	51.78	54.36	54.55	53.56	48.09	52.33	55.66	55.77	52.96
American	45.10	58.76	59.23	55.49	57.83	53.13	56.39	51.35	53.62	45.10	55.95	55.31	53.42	52.45
Mean	45.50	53.66	56.48	55.78	55.32	52.53	45.79	52.19	53.17	45.50	53.12	45.81	53.98	
L.S.D. (P = 0.05) : Cultivar (A) = 0.87 N-Level (B) = 3.11														
N-frequency of appl. (C) = 1.88 A x B = 2.65 A x C = N.S B x C = 3.68 A x B x C = 4.94														
						- 1985 -								
Egyptian	43.78	49.76	52.85	55.08	52.56	51.16	51.20	52.65	51.67	43.78	50.46	52.03	53.07	50.04
Chinese	47.56	50.26	53.78	54.76	52.93	46.44	53.18	54.40	51.34	47.56	48.35	53.48	54.58	50.99
American	44.41	53.93	54.69	50.78	53.13	50.00	53.83	50.63	51.49	44.41	51.97	54.26	50.71	50.34
Mean	45.25	51.32	53.77	53.54	52.87	49.20	52.56	51.50	45.25	50.26	53.26	53.05	52.78	
L.S.D. (P = 0.05) : Cultivar (A) = N.S N-Level (B) = 3.88														
N-frequency of appl. (C) = 1.12 A x B = 3.13 A x C = N.S B x C = 4.51 A x B x C = 5.74														

3.4 The interaction's effect :

With slight exceptions, the interaction between grown cultivar and either level or frequency of N application seems to affect harvest index in a trend similarly to that previously observed economic assimilation rate. Thus, the Chinese cultivar achieved in general, higher harvest indices when relatively high N-levels, i.e. 60 or 90 kg N/fedd., depending on season and growth period, were applied. An exception could be observed in 1984, when the American cultivar receiving 30 kg N/fedd. seemed to achieve the highest HI record at 130 days plant age.

With regards to the interaction of cultivar and frequency of N application, it seems likely that the highest HI is obtained with the Chinese cultivar receiving two equal doses of fertilizer. This result appeared true at 90 and 110 days plant age, whereas 20 days later the American cultivar had higher HI when receiving the same number of N doses.

It is, thus, easily be conclude that the response of garlic plants to either level or frequency of N-applications is dependent on the behaviour of the studied cultivar particularly that deals with the time required for bulbing and maturity.

The interaction between N-level along with its frequency of application affected harvest index in a trend generally similar to that previously observed with EAR. Thus, in general, two equal doses application of 90 kg N/fedd. resulted in the highest harvest indices assessed at the earlier growth periods, i.e. 90 and 110 days from planting. At more advanced growth period, i.e. 130 days plant age, splitting 60 kg N/fedd. for the same number of doses proved to be more effective.

As for the three-factor interaction effect, it is evident to conclude that, with slight discrepancies, two equal doses applications at 90 kg N/fedd. gave the highest harvest index with all tested cultivars.

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مجلة الإمارات للعلوم الزراعية (١٩٩٢) ٤ :

" كفاءة النمو والتمثيل في الثوم وعلاقته بالصنف النامي والتسميد الآزوتي "

ملخص :

تمت دراسة تأثير مستوى التسميد الآزوتي وكذلك عدد مرات إضافته على كفاءة النمو والتمثيل في أصناف الثوم المصري والصيني والأمريكي .

وكانت مقاييس النمو وكفاءة التمثيل هي معدل النمو النسبي ، معدل التمثيل الصافي ، معدل التمثيل الإقتصادي وأيضا مؤشر المحصول .

في المرحلة المبكرة من النمو حقق الصنف المصري أعلى قيم في معدلي النمو النسبي وصافي التمثيل ، بينما أظهر الصنف الصيني تفوقا في معدل التمثيل الإقتصادي في جميع مراحل النمو التي درست ، كما يمكن إعتبار الصنف الصيني ذات قدرة محصولية عالية حيث تميز بقيم عالية لمؤشر المحصول وتبعه في هذا الصنف الأمريكي ثم المصري .

ظهر أن تأثير المستويات المضافة من الأزوت على كلا من معدلي النمو النسبي وصافي التمثيل يختلف حسب فترة النمو للنبات . بجانب هذا وجد أن زيادة مستوي التسميد الآزوتي أدى الى زيادة معدل التمثيل الإقتصادي .

وجد أيضا أن إضافة السماد الآزوتي على مرتين متساويتين كان أكثر تأثيرا في زيادة معدل النمو النسبي مقارنة بإضافة السماد على ثلاث مرات متساوية ، كما أدت إضافة السماد على مرتين متساويتين الى تفوق النباتات في كلا من معدل التمثيل الإقتصادي ومعدل صافي التمثيل .