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Article

The Earliness of Garlic Production by Using Seedlings

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Abstract: This experiment was carried out during two growing winter seasons of 2020/2021 and 2021/2022 at the Vegetable Research Farm (Kaha), Kalubia Governorate. The study investigated the effects of culturing with garlic seedling (Sids-40 clone) of different ages A_1 (four weeks) or A_2 (six weeks) compared to direct planting of cloves as a control A_3 on three early planting dates D_1 (15th August), D_2 (1st September), and D_3 (15th September). The achieved results revealed that, D_3 (15th September) produced the highest survival rate, while D_1 (15th August) gave the fastest germination. and D_2 (1st September) recorded the highest plant length, leaves number/plant, neck and bulb diameter as well as the bulbing ratio. Furthermore, older seedlings of age six weeks exhibited better survival and growth characteristics than younger ones of age 4 weeks or the control, leading to higher yields and improved bulb quality; increased bulb weight, clove number, and nitrogen content. On the other hand, D_3 (15th September) resulted in higher potassium and carbohydrate contents in bulbs. Chlorophyll content was high with D_1 and D_2 which were cultured with older seedlings of age six weeks. The garlic seedlings of six weeks age, which were cultured at D_1 and D_2, were preferable for bulb quality and high yield. This protocol may be useful to overcome climate change in Egypt.

Key words: Seedlings age, early planting, garlic, yield.

1. Introduction

Garlic (*Allium sativum* L.) is a vital vegetable crop and medicinal plant widely cultivated in Egypt, where it plays an essential role in both local consumption and export markets. Garlic was cultivated in ancient Egypt (**FAO, 2011); Ipek and Simon, (2002**), and **Goldy (2000).** Also, it has an important status in Mediterranean, European, and Asian diets as a food diets, as well as a medicinal plant used to treat a variety of ailments. Egypt is the fourth leading country in the world for garlic production after China, India, and Korea (**FAO, 2024).** The early yield of garlic in Egypt is usually available during April, while the main export window to Europe used to be through the period from March up to mid-April. This early yield has vital importance to be exported or to gain a higher price in the local markets **(Ahmed *et al.*, 2020)**.

Agricultural practices such as planting date, cultivar, fertilization and irrigation also have an effect on the growth, yield and the quality of garlic bulbs **(El-Zohiri and Farag, 2014).** The daylength and temperature to which dormant cloves and growing plants are exposed, control the beginning of bulbing, which requires long photoperiods and warm temperature **(Takagi, 1990).** Therefore, earlier planting of garlic cloves will have a longer growth period before bulb initiation, resulting in larger plants with larger bulbs.

Temperature plays a critical role in the main biological activities during plants' growth and development growing degree-days, crop heat unit, or thermal time, is a temperature reaction to development that varies from day to night **(Parthasarathi *et al.*, 2013).** The earlier planting of garlic will have a longer growth phase before bulb initiation, resulting in larger plants yielding large bulbs **(Hassan *et al.*, 2016).** The maximum number of green leaves per plant, leaf area, plant height, cloves number per bulb, bulb diameter, bulb clove weight, and yield (ton/fed.) were higher at the early planting date due to the higher vegetative growth of plants which gives the maximum number of leaves as mentioned by **(El-Zohiri and Farag, 2014).** The number of days from planting to emergence, emergence to bulb development, clove sprouting, leaf growth, bulb initiation, and maturation are the important phenological stages in garlic **(Swati *et al.*, 2013).** The commencement and production of onion bulbs are significantly influenced by the climate. Temperature variations have been proven to benefit the efficiency of vegetative development, leaf initiation, and emergence **(Tesfay *et al.*, 2011).** This investigation aims to study the effect of using seedlings to cultivate garlic in the permanent soil on the productivity and bulb quality of garlic in early cultivation dates as a way to avoid climate change.

2. Materials and Methods

The current trial was carried out during winter seasons of 2020/2021 and 2021/2022 seasons at the Vegetable Research Farm (Kaha), Kalubia Governorate, Egypt. This study aimed to find out the effect of culturing with garlic seedlings (Sids-40 clone) of different ages A_1 (four weeks) or A_2 (six weeks), compared to control A_3 (culturing with cloves directly) on three early planting dates D_1 (15^{th} August), D_2 (1^{st} September), and D_3 (15^{th} September). The site is located at an altitude of 21.1 m above sea level, latitude 30°16' N and longitude 31°12' E. Cloves of Sides-40 clone were used in the present experiment. To break the cloves' dormancy, the bulbs were divided into cloves and were soaked in 5 ppm GA_3 for 24 hours before cultivating in trays (each tray contained 84 eyes) containing a mixture of peat-moss + vermiculite (1:1 v/v) at (1^{st} July, 15^{th} July, 1^{st} August, and 15^{th} August).

The seedlings which were produced from the cultured cloves in the trays were transplanted to the field at the ages of four and six weeks for each planting date [15^{th} August (D_1), 1^{st} September (D_2), and 15^{th} September (D_3)]. For transplanting the seedlings, an experimental plot area of 10.50 m^2 was prepared, divided into 3 rows, each with a length of 5 meters and a width of 0.70 meters. Garlic seedlings were planted on both sides of the rows with a spacing of 10 cm between them. All agricultural practices for cultivation were carried out following the recommendations of the Ministry of Agriculture. The experimental design was a split plot with three replicates. The main plot was the early three planting dates [15^{th} August (D_1), 1^{st} September (D_2), and 15^{th} September (D_3)]. The sub-plots were the planting of seedlings of two ages, four weeks (A_1) or six weeks (A_2) after culturing in trays, as well as cloves directly planted as a control (A_3).

2.1. Data recorded

2.1.1. Survival plant percentage and germination speed

- The survival plant percentage was calculated after 40 days of planting seedlings in the soil by counting the number of surviving plants and applying their number to the following formula:

$$\textbf{The survival percentage} = \frac{\text{Number of survival plants per plot}}{\text{Total number of cultured plants per plot}} \text{ X } 100$$

- **Germination speed** = [(Number of plants in the first day $\times$1) + (No. of plants in the second day $\times$2) + ……. at growth end]/ Total No. of plants **(El Tawashy, 2011)**.

2.1.2. The vegetative growth

Three plants from each experimental sub-plot were uprooted as random samples 150 days after planting (DAP) to determine plant length (cm) (measured from the base of the swelling sheath to the tip of the largest linear blade in the plant), number of leaves per plant neck and bulb diameter (cm), bulbing ratio, and fresh weight of leaves (average weight of plant after the removal of its bulbs at the neck zone), and bulb weight (gm). The leaves and bulb dry weight (gm), (leaves and bulbs were measured by drying them in an electric oven to constant weight at 70 °C). Chlorophyll reading was measured using SPAD (using TYS-B chlorophyll meter, China). Free Proline content in leaves was determined at 150 (DAP) according to the method of **Bates *et al.* (1973).**

2.1.3. Yield components

The total yield (ton per fed.) was determined for each experimental sub-plot at the harvest time (at 180 days after planting approximately). The curing process was carried out on the plants by placing them for 15 days in an aerated area. After the curing process, five bulbs were taken randomly from each experimental sub-plot to determine the averages of bulb length and diameter (cm) (measured by using Bioclase), bulb weight (gm), cloves number per bulb, and clove weight(gm).

The total carbohydrates were determined colorimetrically in the digested dry matter of the bulbs according to **James (1995).** Total nitrogen was determined according to the method described by **Pregl (1945)** using a micro-kjeldahl apparatus. Meanwhile, phosphorus was determined in the dry matter of bulbs according to **A.O.A.C. (1990).** Likewise, potassium was determined by flame-photometrically as described by **Brown and Lilleland (1946).** Crude protein was calculated as nitrogen content x 6.25.

2.2. Statistical analysis

A split-plot design with three replicates was used. The obtained data of both seasons were subjected to the analysis of variance method, and the means of the treatments were compared by using the least significant difference (L.S.D) at the level of 0.05 probability according to **Snedecor and Cochran (1991).**

3. Results

Survival and germination percentage are clear from the presented data in Table 1 that the third planting date 15th September (D_3) recorded the highest significant effect on the survival plant percentage, while the highest germination speed was obtained in the first planting date 15th August (D_1) followed by the third planting date 15th September (D_3) in both seasons.

In addition, data illustrated that the six weeks age seedling (A_2) gave the highest significant effect on the survival plant percentage, without a significant difference between the two seedling ages in the second season. The second seedling age A_2 (six weeks) recorded the highest significant germination speed, followed by the younger seedling age A_1, but this effect was true in the first season only.

Concerning the interaction between the planting date and the seedling age, the results in Table 1 showed that the highest significant survival plants were recorded with the third planting date, (D_3), and both seedling ages. The highest significant germination speed is stated through the first planting date (D_1) with the second seedling age A_2.

Plant growth second planting date (D_2) led to the highest significant effect on the plant length, number of leaves per plant, neck diameter, and bulb diameter in both seasons (Table 2).

The second seedling age (A_2) followed by the first seedling age (A_1) gave the highest significant plant length in both seasons, although, number of leaves per plant did not reach a significant level in both seasons (Table 2). In otherwise, the superiority of A_2 followed by the first seedlings' age A_1 in neck diameter was in the first season only and with the bulb diameter in the second season only.

The interaction effect between the different planting dates and seedling ages (Table 2), cleared that the second planting date with first, second seedling ages and control gave the highest significant plant length, neck diameter, and bulb diameter in both seasons, as well as the number of leaves per plant in the second season only.

As reported in Table 3, data showed clearly that the third planting date (D_3) gave the lowest significant bulbing ratio, whereas the first (D_1) and the second (D_2) planting dates recorded the highest leaves fresh weight /plant in both seasons. The second planting date (D_2) gave the heaviest bulb fresh weight in both seasons.

The bulbing ratio recorded the lowest significant values with the cloves planted directly through the first season only, while the first (A_1) and the second (A_2) seedlings age had a significant effect on leaves fresh weight in both seasons (Table 3).

The result in Table 3 indicated the interaction between different planting dates and seedling ages. The lowest bulbing ratio was produced in cloves planted directly (control) on 15th September (D_3) during both seasons. On the other point of view, the highest leaves fresh weight was recorded with the first and second planting dates with first and second seedling ages in both seasons. The heaviest bulb fresh weight was recorded by first planting date with the second seedling age and with direct planted clove (control) as well as the second planting date with the two seedling ages and control in both seasons.

Table (1). Effect of planting date and seedling age on survival plants percentage and germination speed in the seasons of 2020/2021 and 2021/2022

Planting date	Seedlings age	Survival plants percentage (%)		Germination speed (days)	
		2020/2021	2021/2022	2020/2021	2021/2022
D_1		74.00	71.26	11.52	12.06
D_2		72.11	69.85	18.19	18.16
D_3		82.48	80.37	14.29	13.86
L.S.D. ≤ 5%		**3.98**	**4.43**	**3.13**	**3.05**
	A_1	75.96	74.33	14.65	14.98
	A_2	80.15	75.81	13.30	13.79
	A_3	72.48	71.33	16.06	15.33
L.S.D. ≤ 5%		**3.53**	**3.68**	**1.77**	**N.S**
D_1	A_1	74.55	70.77	10.92	13.05
	A_2	78.33	70.77	10.52	10.46
	A_3	69.11	72.22	13.11	12.68
D_2	A_1	72.22	72.55	17.05	16.65
	A_2	75.00	71.33	17.1	17.70
	A_3	69.11	65.66	20.51	20.14
D_3	A_1	81.11	79.66	15.97	15.23
	A_2	87.11	85.33	12.35	13.20
	A_3	79.22	76.11	14.56	13.16
L.S.D. ≤ 5%		**6.11**	**6.38**	**3.07**	**3.75**

Main effect: [(D1) 15th August, (D2) 1st September, and (D3) 15th September].
Sub main effect: (A1) four weeks, (A2) six weeks and (A3) cloves directly planted as a control

Table (2). Effect of planting date and seedlings age on plant length (cm), number of leaves/plant, neck diameter (cm), bulb diameter (cm), and bulbing ratio at 150 DAP in the seasons of 2020/2021 and 2021/2022

Planting date	Seedling age	Plant length (cm)		Number of leaves / plant		Neck diameter (cm)		Bulb diameter (cm)	
		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
D_1		68.67	65.33	10.06	9.33	1.54	1.39	4.49	4.37
D_2		82.78	85.00	10.11	11.06	1.81	1.77	5.19	5.32
D_3		65.44	60.11	9.11	9.06	1.10	1.26	4.01	4.04
L.S.D. ≤ 5%		**7.37**	**3.89**	**0.88**	**0.92**	**0.19**	**0.30**	**0.66**	**0.41**
	A_1	72.67	70.56	978	9.83	1.48	1.44	4.62	4.63
	A_2	73.89	72.00	10.00	10.39	1.54	1.60	4.89	4.66
	A_3	70.33	67.89	9.50	9.22	1.43	1.37	4.18	4.44
L.S.D. ≤ 5%		**2.22**	**3.47**	**N. S.**	**N.S**	**N.S.**	**0.22**	**0.49**	**N.S.**
D_1	A_1	68.00	64.67	10.00	10.00	1.50	1.23	4.53	4.03
	A_2	71.00	68.00	10.33	9.33	1.83	1.60	4.87	4.30
	A_3	67.00	63.33	9.83	8.67	1.30	1.33	4.07	4.77
D_2	A_1	83.67	85.67	10.67	10.83	1.80	1.67	5.40	5.30
	A_2	84.00	87.00	10.00	12.00	1.67	1.97	5.37	5.53
	A_3	80.67	82.33	9.67	10.33	1.97	1.67	4.80	5.13
D_3	A_1	66.33	61.33	8.67	8.67	1.13	1.43	3.93	4.57
	A_2	66.67	61.00	9.67	9.83	1.13	1.23	4.43	4.13
	A_3	63.33	58.00	9.00	8.67	1.03	1.10	3.67	3.43
L.S.D. ≤ 5%		**3.85**	**6.01**	**N.S**	**2.05**	**0.37**	**0.39**	**0.85**	**0.79**

Main effect: [(D_1) 15th August, (D_2) 1st September, and (D_3) 15th September].
Sub main effect: (A_1) four weeks, (A_2) six weeks and (A_3) cloves directly planted as a control

Table (3). Effect of planting date and seedlings age on bulbing ratio, leaves fresh weight (gm) and bulb fresh weight (gm) at 150 DAP in the seasons of 2020/2021 and 2021/2022

Planting date	Seedlings age	Bulbing ratio		Leaves fresh weight /plant (gm)		Bulb fresh weight (gm)	
		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
D_1		0.95	0.865	72.71	76.57	55.85	60.06
D_2		1.096	1.106	73.73	78.06	62.49	66.7
D_3		0.682	0.789	65.35	69.04	50.87	56
L.S.D. ≤ 5%		**0.139**	**0.299**	**4.68**	**7.25**	**3.96**	**5.36**
	A_1	1.48	0.898	73.18	77.23	55.56	59.8
	A_2	0.772	1.03	73.56	77.39	58.35	62.44
	A_3	0.478	0.832	65.05	69.05	55.29	60.54
L.S.D. ≤ 5%		**0.156**	**N.S**	**6.29**	**5.8**	**N.S.**	**N.S.**
D_1	A_1	1.5	0.75	80.18	84.04	53.92	58.02
	A_2	0.917	1.061	71.05	74.9	57.36	61
	A_3	0.433	0.783	66.91	70.76	56.26	61.17
D_2	A_1	1.8	1.061	77.38	81.98	66.38	70.56
	A_2	0.833	1.239	76.19	80.5	64.55	69.13
	A_3	0.656	1.017	67.61	71.7	56.53	60.43
D_3	A_1	1.133	0.883	61.99	65.67	46.39	50.81
	A_2	0.567	0.789	73.44	76.77	53.14	57.18
	A_3	0.344	0.694	60.62	64.69	53.06	60.02
L.S.D. ≤ 5%		**0.27**	**0.351**	**10.9**	**10.04**	**11.47**	**11.01**

Main effect: [(D_1) 15th August, (D_2) 1st September, and (D_3) 15th September].

Sub main effect: (A_1) 4 weeks, (A_2) 6 weeks and (A_3) cloves directly planted as a control The second (D_2) and the third (D_3) planting dates led to the heaviest leaves dry weight in the second season only, while the first (D_1) and the second (D_2) planting dates recorded the highest bulb dry matter and chlorophyll content in both seasons. The highest significant content of proline was found in the first and the second planting dates in the first season only (Table 4).

The second seedling age (A_2) followed by the first seedling age (A_1) gave the highest significant leaves and bulbs dry matter in the first season only (Table 4). The highest significant chlorophyll content found with the second seedling age (A_2) in the first season, while, in the second season the second (A_2) and the first (A_1) seedling ages which gave the highest significant content. The seedling age effect on the proline content did not reach a significant level in both seasons.

Table (4). Effect of planting date and seedling age on leaves dry matter (%), bulb dry matter (%), chlorophyll content (spad) and proline content (μ mole/gm) at 150 DAP in the seasons of 2020/2021 and 2021/2022

Planting date	Seedlings age	Leaves dry matter (%)		Bulb dry matter (%)		Chlorophyll Content (spad)		Proline content (μ mole/gm)	
		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
D_1		22.05	20.96	29.2	28.96	59.53	59.93	49.93	44.7
D_2		22.12	22.65	30.34	30.82	60.87	61.36	47.54	45.94
D_3		21.08	21.81	26.41	27.16	54.22	57.5	41.97	44.74
L.S.D. ≤ 5%		**N.S.**	**1.16**	**2.48**	**3.17**	**2.82**	**3.03**	**2.91**	**N.S**
	A_1	22.35	21.78	28.22	28.58	58.26	59.59	46.74	44.7
	A_2	22.37	22.12	30.01	29.76	60.77	62.21	46.08	45.94
	A_3	20.53	21.52	27.72	28.59	55.6	56.99	46.61	44.74
L.S.D. ≤ 5%		**1.12**	**N.S.**	**2.21**	**N.S.**	**2.33**	**3.35**	**N.S**	**N.S**
D_1	A_1	22.25	19.55	28.68	28.24	57.43	58.8	48.89	47.86
	A_2	21.98	21.82	31.48	29.3	62.07	61.2	50.38	48.99
	A_3	21.93	21.5	27.44	29.35	59.1	59.8	50.53	48.61
D_2	A_1	24.89	23.32	29.16	30.62	63.73	64.33	48.19	45.31
	A_2	21.9	23.1	31.84	31.1	65.33	64.93	45.66	48.24
	A_3	19.56	21.5	30.03	30.74	53.53	54.8	48.77	45.7
D_3	A_1	19.92	22.46	26.82	26.9	53.6	55.63	43.16	40.93
	A_2	23.23	21.45	26.73	28.89	54.9	60.5	42.21	40.28
	A_3	20.09	21.51	25.68	25.69	54.17	56.37	40.53	39.91
L.S.D. ≤ 5%		**1.95**	**2.11**	**3.82**	**4.34**	**4.03**	**5.8**	**4.74**	**4.79**

Main effect: [(D_1) 15th August, (D_2) 1st September, and (D_3) 15th September].
Sub main effect: (A_1) four weeks, (A_2) six weeks and (A_3) cloves directly planted as a control

As shown in the same Table the highest leaves dry weight was recorded with the interaction between the second planting date and the first seedlings age or the third planting date and the second planting date in the first season; whereas, in the second one all the planting dates with all the seedling ages gave high values except the first planting date with first seedlings age. The heaviest bulb dry matter was recorded by the first planting date interacted with the first and second seedlings age in the first season while in the second one the highest values were recorded by the second planting date with both seedlings age and control. The highest chlorophyll content found with the interaction between the first planting date and the second seedlings age, or the second planting date and the two seedlings ages in the first season whereas in the second season highest values obtained by the first planting date planted with the second seedlings age or control, the second planting date with the first and the second or the third planting date with the second seedlings age. The highest proline content was shown as a result of the first and second planting dates, with the first and the third seedling ages in the first season, while in the second season, the highest proline content was recorded in the first and second planting dates, with all the seedling ages under study.

Yield and its components in Table 5 show that the heaviest bulb weight was recorded with the first planting date in both seasons. The highest bulb diameter and total yield were recorded by the first and the second planting date in the first season, while, in the second season the highest values were recorded with the second planting date. The highest number of cloves/bulbs was recorded with the first and the second planting dates in both seasons.

The seedlings age effect was significant on the bulb weight in the second season only with superiority for the second seedling age followed by the first seedling age for bulb weight and diameter in both seasons (Table 5). The highest cloves number/bulb was recorded with the second seedling age in both seasons. concerning the highest total yield obtained with the second seedling age in the first season, and the second seedling age followed by the first seedling age in the second season.

Table (5). Effect of planting date and seedling age on bulb weight (gm), bulb diameter (cm), number of cloves per bulb and total yield (ton/fed.) at 180 DAP in the seasons of 2020/2021 and 2021/2022

Planting date	Seedlings age	Bulb weight (gm)		Bulb diameter (cm)		Number of cloves per bulb		Total yield (ton/fed.)	
		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
D_1		70.30	71.94	5.36	5.66	16.84	15.92	9.43	9.40
D_2		63.13	64.12	5.61	7.06	17.69	17.92	9.41	9.81
D_3		60.83	62.33	5.19	5.48	13.62	14.73	6.55	7.41
L.S.D. ≤ 5%		**3.58**	**4.58**	**0.36**	**0.37**	**1.12**	**2.19**	**0.32**	**0.23**
	A_1	65.01	66.58	5.39	6.01	15.54	16.43	8.30	8.79
	A_2	67.45	68.68	5.58	6.30	17.52	17.98	9.15	9.23
	A_3	61.80	63.13	5.19	5.88	15.10	14.24	7.94	8.60
L.S.D. ≤ 5%		**N.S.**	**3.3**	**0.22**	**0.34**	**1.40**	**1.09**	**0.59**	**0.48**
D_1	A_1	65.86	66.81	5.50	5.63	16.66	16.99	9.33	10.03
	A_2	73.54	76.29	5.30	6.00	17.19	16.99	10.50	9.43
	A_3	71.50	72.71	5.27	5.33	16.66	13.99	8.44	8.74
D_2	A_1	62.15	60.95	5.37	7.30	15.63	17.18	9.31	9.67
	A_2	66.66	71.49	6.07	7.23	21.16	20.63	9.97	10.2
	A_3	60.57	59.91	5.40	6.63	16.29	15.96	8.94	9.46
D_3	A_1	67.01	71.98	5.30	5.10	14.33	15.11	6.25	6.68
	A_2	62.14	58.24	5.37	5.67	14.19	16.33	6.97	7.96
	A_3	53.32	56.76	4.90	5.67	12.33	12.77	6.43	7.59
L.S.D. ≤ 5%		**10.01**	**5.71**	**0.38**	**0.59**	**2.43**	**1.89**	**1.03**	**0.83**

Main effect: [(D_1) 15th August, (D_2) 1st September, and (D_3) 15th September].
Sub main effect: (A_1) four weeks, (A_2) six weeks and (A_3) cloves directly planted as a control

The interaction between the first planting date with all seedling ages (A_1, A_2) and Control, as well as the second planting date with the second seedling age, and the third planting date with the first seedling age yielded the heaviest bulb weight through the first season (Table 5). However, in the second season the heaviest bulb weight was obtained by the interaction between first planting date with the second seedling age (A_2) or the control treatment, as well as the second planting date with the second seedling age or the third planting date with the first seedling age (Table 5). The highest bulb diameter was observed with the second planting date, corresponding to the second and first seedling ages in the first and second seasons, respectively. The interaction between the second planting date and the second seedling age yields the highest clove number per bulb in both seasons. The highest total yield was obtained by the first and second planting dates with the second seedling age in the first season, whereas in the second season, the first planting date with the first seedling age or the second planting date with the first and second seedling ages recorded the heaviest total yield.

The greatest nitrogen content was gained with the first and the second planting dates in the first season, while in the second season the second planting date was the greatest one (Table 6). Phosphorus percent was not affected by planting date treatments in both studied seasons. The potassium percent significantly increased with the second and the third planting date in both seasons. The highest total carbohydrate percent was recorded with the third planting date in both seasons. The highest significant protein percent was obtained with the first and the second planting dates in the first season, while the highest values were recorded with the second planting date only in the second one.

Table (6). Effect of planting date and seedling age on nitrogen (%)**, phosphorus** (%)**, potassium** (%)**, total carbohydrate** (%)**, and protein (%) at 180 DAP in the seasons of 2020/2021 and 2021/2022**

planting date	Seedlings age	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Total carbohydrate (%)		Protein (%)	
		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
D_1		2.83	2.32	0.271	0.274	1.488	1.563	25.08	26.78	17.69	14.48
D_2		2.53	2.65	0.275	0.277	1.703	1.687	26.6	27.63	15.84	16.56
D_3		2.37	2.19	0.284	0.279	1.779	1.682	30.87	32.25	14.81	13.67
L.S.D. ≤ 5%		**0.33**	**0.29**	**N.S.**	**N.S.**	**0.233**	**0.021**	**2.98**	**3.62**	**2.036**	**1.78**
	A_1	2.46	2.28	0.28	0.276	1.704	1.573	26.54	27.77	15.35	14.28
	A_2	2.97	2.67	0.276	0.271	1.63	1.7	27.2	28	18.55	16.69
	A_3	2.31	2.2	0.274	0.281	1.636	1.661	28.81	30.89	14.45	13.75
L.S.D. ≤ 5%		**0.34**	**0.43**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**2.15**	**2.7**
D_1	A_1	2.54	2.18	0.281	0.273	1.487	1.427	23.31	28.03	15.85	13.65
	A_2	3.11	2.6	0.265	0.264	1.94	1.723	26.41	24.91	19.42	16.25
	A_3	2.85	2.42	0.268	0.285	1.487	1.54	25.5	27.39	17.81	13.54
D_2	A_1	2.65	2.68	0.267	0.279	1.817	1.65	26.17	26.59	16.54	16.77
	A_2	2.89	2.85	0.286	0.275	1.64	1.73	24.85	24.55	18.04	17.79
	A_3	2.07	2.42	0.272	0.275	1.653	1.68	28.79	31.75	12.94	15.13
D_3	A_1	2.18	1.99	0.292	0.276	1.81	1.643	30.14	28.69	13.65	12.42
	A_2	2.91	2.56	0.277	0.275	1.76	1.64	30.33	34.53	18.19	16.02
	A_3	2.02	2.01	0.283	0.284	1.767	1.763	32.14	33.51	12.6	12.58
L.S.D. ≤ 5%		**0.6**	**0.75**	**N.S.**	**N.S.**	**0.267**	**N.S,**	**6.14**	**8.82**	**3.72**	**4.67**

Main effect: [(D_1) 15th August, (D_2) 1st September, and (D_3) 15th September].
Sub main effect: (A_1) four weeks, (A_2) six weeks and (A_3) cloves directly planted as a control

The effect of different seedling ages on nitrogen percent was obtained with the second seedling age in the first season, and the second seedling age followed by the first seedling age in the second season. phosphorus percent and potassium percent did not reach to significant level in both seasons (Table 6). The effect of seedling age on total carbohydrate percent did not reach to significant level in both seasons. The highest protein values were recorded by the second seedling age only in the first season, while in the second season, by the second seedling age, followed by the first one.

The interaction between the first planting date and the second and third seedling age, as well as, the second planting date with the first and second seedling ages, and the third planting date with the second seedling age in the first season, recorded the highest nitrogen percent, while in the second season the highest content found in the interaction between the first and the second planting dates with all studied seedling ages (A_1, A_2, and A_3), in addition to the third planting date with the second seedling age. Otherwise, phosphorus percent did not reach a significant level in both seasons (Table 6). However, it has a significant effect in the first season only on potassium percent, with the highest values recorded for the first and second planting dates across all seedling ages. The highest carbohydrate percent was observed in the first planting date with the second seedling age, the second planting date with the control, and the third planting date with all seedling ages. In contrast, in the second season, all planting dates had the highest carbohydrate percent at the first and third seedling ages. The highest protein percent was recorded as a result of the first planting date with all seedling ages, the second planting date with the third and second seedling ages, and the third planting date with the second seedling age in the first season, while in the second season, the highest protein values were gained by the first planting date with first and the second seedling ages, the second planting date with all the seedling ages and the third planting date with the second seedling age.

4. Discussion

Despite numerous scientific reports concerning planting dates and seedling ages are the most critical factors that determine the yield and the quality of garlic plants. Different significant effects occurred due to the different planting dates obtained. The planting date D_3 (15th September) resulted in the highest survival rates across both seasons, due to favorable climatic conditions for young seedlings at this timing. These results are in harmony with those mentioned by **El-Zohiri and Farag (2014), Rahman *et al. (*2004) and Kaur *et al.* (2022)**. Meanwhile, the second date D_2 (1st September) promoted faster germination. Moreover, the second planting date (D_2) produced the most vigorous plants exhibiting greater plant length, number of leaves per plant, neck and bulb diameter, and bulbing ratio. Earlier (D_1) or later (D_3) dates led to reduced performance, suggesting an optimal window for transplanting avoids both excessive summer heat and late-season stress this are in agreement with those found by **El-Zohiri and Farag (2014), Youssef and Tony (2014), Hassan *et al.* (2016) and Kaur *et al.* (2022)** who stated that early planting encourages cell division and meristematic elongation, which support the plants' vegetative growth and aid in the synthesis of more photosynthates, which in turn leads to a greater buildup of carbohydrates.

Concerning the age of transplanting seedlings, older seedlings A_2 (six weeks) generally achieved higher survival and growth, especially in terms of neck diameter and bulb diameter. This reflects their greater resilience during transplant shock and robust established root systems, which facilitate nutrient uptake and vigor post-transplant. These results are in the same line with the findings of **Rahman *et al.* (2004)** and **El-Shabasi *et al.* (2018)**. Chlorophyll content, an indicator of photosynthetic capacity, was highest with the first and second planting date and older seedlings, further supporting the benefit of transplanting appropriately aged seedlings before late September. These findings are similar to those obtained by **Hassan *et al.* (2016) and Kaur *et al* (2022).**

Highest yields and bulb quality were frequently linked to early plantation (D_1 and D_2). The use of 6-week-old seedlings (A_2) resulted in consistently higher bulb weights, total yields, and clove numbers per bulb, underscoring the advantage of transplanting more robust, developed seedlings to achieve abundant harvests. The results are a copy of those illustrated by **El-Zohiri and Farag (2014) and Ahmed *et al.* (2020)** who mentioned that the early planting date resulted in higher total fresh yield and total cured yield as compared to the latest planting date. Also, **Nourai (2004)** found that the high garlic yields obtained from early sowings were associated with an increased bulb and clove weight also Early sowing increased bulb diameter and improved garlic quality.

Nitrogen and protein content were maximized with earlier planting dates and older seedlings, as a result of enhanced vegetative development and longer periods for nutrient accumulation. Meanwhile, later planting dates (D_3) increased potassium and total carbohydrate concentration in bulbs, as an adaptive response to shorter growth durations and altered physiological states at maturity. (**Kaur *et al.* 2022).** From another point of view, elevated plant proline concentrations in earlier dates reflect physiological adaptation to initial establishment stress, enhancing early-season resilience.

In general, the results indicate significant advantages of using seedlings, specifically those aged 6 weeks, for transplanting in early to mid-planting dates. This approach not only advances harvest dates but also promotes higher yields and better bulb quality.

5. Conclusions

The study robustly demonstrates that the earlier planting date with the use of seedlings is a superior strategy for enhancing garlic growth, yield, and early market readiness. These findings contribute valuable evidence supporting the use of seedlings in effective, climate-smart garlic production systems under Egyptian conditions.

References

A.O.A.C. (1990). Association of Official Analytical Chemists. Official Methods of Analysis (15th Ed.) Washington, D.C., U.S.A.

Ahmed, S.; Ibrahim A.A.A. and Farag M. F. (2020). Interaction effects of planting date or/and clove weight on growth, yield, storability and severity of downy mildew disease on two garlic cultivars. Egypt. J. Agric. Res., 98 (2), 214-239.

Bates, L. S; waldren, J. R. P. and Teare, I. D. (1973). Rapid determination of free proline for water-stress studies. Plant and Soil, 39: 205-207.

Brown, I.D. and Lilleland, O. (1946). Determination of potassium and sodium in plant material and soil extracts by flame photometry Proc. Amer. Soc. Hort. Sci., 48:341-346.

El-Shabasi, M.S.S.; Osman, Y.M.M. and Rizk, S.M. (2018). Effect of planting date and some pre-planting treatments on growth and yield of Garlic. J. Plant Production, Mansoura Univ., 9 (12): 1091 – 1096.

El Tawashy, M.M.K. (2011). Studies on propagation and breeding on artichoke. Thesis M.Sc. Faculty of Agriculture, Cairo Univ., P. 78.

El-Zohiri, S.S.M and Farag, A.A. (2014). Relation planting date, cultivars and growing degree-days on growth, yield and quality of garlic, Middle East. J. of Agric. Res., 3(4):1169-1183.

F.A.O. (2001). Food and Agriculture Organization Rome: The Origin and Distribution of Garlic USDA Agricultural Research Unit, USA pp. 98-108.

F.A.O. (2024). Statistical Yearbook. Food and Agriculture Organization (FAO), Rome, Italy.

Goldy, R. (2000). Producing Garlic in Michigan, Michigan State University Extension. Gene, B., 2009: Garlic Huntington College of Health Sciences, Literature Education Series on Dietary Supplements.

Hassan, G.H.; El-Shal, M.A.; Soliman, K.H.A. and Ghoneim, I.M. (2016). Effect of planting dates and periods of Curing on quantitative, qualitative characteristics and storage ability of two garlic cultivars. J. Agric. Res. Kafr El-Sheikh Univ., 42 (3): 401-414.

Ipek, M. and Simon, P. (2002). Evaluation of genetic diversity among garlic clones using molecular markers: comparison of AFLPS, RAPDS and ISOZYMES. Plant and Animal Genome. X Meeting.January 12-16.

James, C.S. (1995). Analytical chemistry of foods. Blokie Academic and Professional, London.

Kaur K.; Kaur, A. and Singh, M. (2022). Effect of planting time and planting methods on the performance of garlic (*Allium sativum* L.) under Punjab conditions. The Pharma Innovation Journal 2022; 11(9): 2431-2435.

Nourai, A.H. (2004). Effects of Planting Dates on Yield and Quality of Garlic (*Allium sativum* L.) in Northern Sudan . Gezira J. of Agric. Sci. 2(2): 197-205 (2004)

Parthasarathi, T.; Velu, G. and Jeyakumar, P. (2013). Impact of crop heat units on growth and developmental physiology of future crop production: A Review Research & Reviews: A Journal of Crop Science and Technology Volume 2, Issue 1, ISSN: 2319–3395.

Pregl, E. (1945). Quantitative Organic Microanalysis. 4thEd. J. Chundril, London.

Rahman, S.; Islam, A.; Haque, S. and Abdul-Karim (2004). Effects of planting date and gibberellic acid on the growth and yield of garlic (*Allium sativum* L.). Asian J. of Plant Sciences, 3(3): 344-352

Snedecor, G.W. and Cochran, W.G. (1991). Statistical Method.8th Ed., Iowa State Univ. Press, Ames, Iowa, USA.

Swati, B.; Kirad, K.S. and Shrivastav, A.K. (2013). Effect of Planting Dates on Growth and Yield on Garlic (*Allium sativum* L.), International Journal of Horticulture, 3 (4).16-18.

Tesfay, S.Z.; Bertling, I.; Odindo, A.O.; Greenfield, P.L. and Workneh, T.S. (2011). Growth responses of tropical onion cultivars to photoperiod and temperature based on growing degree-days. African J. of Biotechnology, 10 (71): pp. 15875-15882.

Youssef, N.S. and Tony, H.S.H. (2014). Influence of different planting date on the performance of new garlic genotypes grown under El-Minia governorate conditions. Nature and Science, 12 (5): 112-119.