



Article

Effect of Clove Weight and Nitrogen Fertilization on Garlic Growth, Productivity and Quality

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Abstract: Two prosperous field trials were executed during 2023/2024 and 2024/2025 seasons at Kaha Vegetable Research Farm, Kaliobia Governorate, Egypt. This investigation aimed to examine the influence of planting garlic seed cloves three sizes (small <1.5g, medium 1.5-3.0g and large >3.0g) and applied N fertilizer at different rates (90, 120 and 150 unit of N/fed) on plant growth, yield and chemical constituents of Balady garlic cultivar. The results recorded planting large cloves (>3g) with 150 unit of N/fed gave the highest plant length, neck and bulb diameter, plant fresh, plant dry weight. As well as, planting large cloves (>3g) or medium cloves (1.5-3g) with 150 unit of N/fed gave the heights values of total yield at harvest time, total yield after curing, bulb weight, neck diameter, bulb diameter, bulb dry matter, N, K and crude protein in dry matter of the bulbs. Planting small cloves (<1.5g) with 90 unit of N/fed or planting cloves (>3.0g) with 120 unit of N/fed gave the heights values of pungency. The study recommends the planting with large size cloves (>3.0g) or medium (1.5-3.0g) with 150 unit of N/fed for both sizes to optimize the productivity and quality of garlic plant.

Key words: *Allium sativum* L., Weight of clove in planting, Nitrogen fertilization, Yield

1. Introduction

Garlic (*Allium sativum* L.) is one of the most often grown vegetable crops and the second most popular bulb crop after onions. Worldwide, garlic ranks second only to onion in terms of consumption. In 2024, Egypt produced approximately 558,228.44 tons of garlic from 21,642 hectares (**FAOSTAT, 2026**). In recent years, Egypt has witnessed a significant surge in interest regarding the expansion of garlic cultivation, driven by escalating domestic consumption and a rapidly growing export market. From an economic standpoint, national agricultural policies and research must prioritize maximizing productivity per unit area while simultaneously enhancing bulb quality to sustain market competitiveness. Achieving these strategic goals relies heavily on adopting optimized agronomic practices. Key among these interventions are the selection of appropriately sized cloves for propagation,

the calibration of precise nitrogen fertilization rates, and the implementation of rigorous post-harvest management. The grading of garlic cloves before planting is crucial for achieving large yields and superior quality (Ibrahim *et al.*, 2020). An extreme relationship was reported between the large clove size and plant production, which reflected on higher yields (Brewster, 2008). Furthermore, D'Anna *et al.* (1997) confirmed that large cloves produced a larger bulb, higher dry weight, and yield, whereas small cloves produced small plants and reduced dry weights. Rahman *et al.* (2004), Noorbakhshian *et al.* (2008) stated that clove weight has the maximum primitive effect on the yield characters. Albaba *et al.* (2020) demonstrated that increasing the clove size used in garlic cultivation had a positive effect on the vegetative characteristics. Also, planting of 3-3.5g cloves enhance vegetative growth and total bulb yield of garlic (Desta *et al.*, 2021).

Nitrogen (N) is the plant nutrition macro-element that plants need in the greatest amounts and is a primary factor influencing crop productivity; it is integral to plant metabolism as a component of proteins, nucleic acids, chlorophyll, coenzymes, phytohormones, and secondary metabolites (Rengel *et al.*, 2022). Many studies reported that the vegetative growth of garlic plants and nitrogen uptake were increased with increasing the level of N fertilizers (Ahmed *et al.*, 2012; Samy and El-Zohiri, 2021 and Shafeek *et al.*, 2021). Moreover, the N positively affected the growth and bulb yield of garlic plants (Kevlani, *et al.* 2023).

The objective of this study was to elucidate the effect of clove weight and nitrogen fertilization treatments in order to enhance the growth, yield and quality of Balady cv. garlic plants.

2. Materials and Methods

The present investigation was conducted during winter seasons of 2023/2024 and 2024/2025 at Kaha Vegetable Research Farm, Kaliobia Governorate, Egypt. The soil composition exhibited a clay loam textural classification, characterized by a pH measurement of 7.49 and an electrical conductivity value of 1.94 decisiemens per meter. The Balady cultivar used in the study was obtained from the Potato and Vegetable Vegetatively Propagated Vegetables Research Dep., (HRI). A split plot design with 3 replicates was adopted. The weight of cloves (small <1.5g, medium 1.5-3.0g and large >3.0g) represented the main plots. The sub-plots were 3N fertilizer treatments *i.e.*, Ammonium sulfate (20.6% N) applied at different rates 90, 120 and 150 unit of N/fed represented 75, 100 and 125% from recommended dose in three equal doses, the first one applied as soil application after 30 days from planting date and repeated every 30days. All treatments received the following fertilizers supper calcium phosphate (15.5% P₂O₅) applied at rate 75 unit of P₂O₅ /fed, potassium sulphate (48% K₂O) applied at rate 72 unit of K₂O/fed in three equal doses, starting from the first irrigation.

The experimental sub-plot area measured 10.50 m² and was composed of 3 ridges, each extending 5 m in length with a width of 0.70 m. Garlic cloves were planted on both sides of the ridges at 10 cm apart. The planting date was 10th of October in the first and second seasons. Surface irrigation was followed. The Balady cultivar used in the study was obtained from the Potato and Vegetable Vegetatively Propagated Vegetables Research Dep., (HRI).

Agricultural cultivation practices were executed in accordance with the directives and recommendations established by the Ministry of Agriculture. The cultivation was carried out in clay soil that was laboratory analyzed according to the procedures, established by Jackson (1973) and the average of the obtained data are shown in Table 1.

Table (1). Physical and chemical properties of the experimental soil

Season	Physical properties			Chemical properties (ppm)		
	Clay%	Silt%	Sand%	Available N	Available P	Available K
2023/2024	61.80	18.65	19.55	95.56	5.54	209.44
2024/2025	60.18	19.33	19.37	92.77	4.63	211.36

Data recorded

Vegetative Growth Characters

Random samples comprising three plants were extracted from each experimental plot following a 150day interval from the initial planting date to determine plant length (cm), leaf number per plant, neck and bulb diameter (cm), bulbing ratio was calculated according to the formula described by **Mann (1952)** as follow: Bulbing ratio = (bulb neck diameter (cm)/bulb diameter (cm)), fresh and dry weight of plant (g).

Total yield and its components

Total yield was determined for each experimental plot at harvest. After curing period for 30 days under shaded place, plants of each experimental plot were weighed and total cured yield was calculated as ton per feddan (4200 m²= 0.42 hectare). Five bulbs were randomly selected from each experimental sub-plot in order to calculate the mean bulb weight (g), neck diameter (cm), bulb diameter (cm.), bulb diameter (cm), Bulbing ratio and Bulb dry matter%. The estimation of weight loss percentage to the curing process is determined through the application of the subsequent formula:

$$\text{Weight loss after curing} = \frac{(\text{Total yield at harvest time} - \text{Cured yield}) \times 100}{\text{Total yield at harvest time}}$$

Chemical constituents

Total carbohydrate content was determined according to **James (1995)**. In addition, 0.2 g of the dried ground material was digested with a mixture of H₂SO₄ and HClO₄ following **A.O.A.C. (2016)**. In the resulting digest, N was measured using a micro-Kjeldahl apparatus, P spectrophotometrically, and K by flame photometry (**Page et al., 1982**). Protein content was estimated by multiplying the N concentration by a factor of 6.25(**Ranganna, 1977**). Pungency intensity was determined as a quantifiable function of pyruvic acid levels utilizing the colorimetric analytical procedure that was delineated by **Schwimmer and Weston (1961)**.

Statistical analysis.

Data were subjected to ANOVA according to **Snedecor and Cochran (1991)** using Statistix 10 software. Means were compared using LSD test ($P \leq 0.05$).

3. Results

1- Vegetative growth characters

The data presented in the Tables 2 and 3 that there were significant differences between planting with different sizes of cloves (small <1.5g, medium 1.5-3.0g and large >3.0g) in plant length, number of leaves / plants, nick and bulb diameter, bulbing ratio, fresh and dry weight of plant. Although, the differences were non-significant for nick diameter and bulbing ratio in the 2nd season. In this respect, planting the large size cloves (>3.0g) exhibited the highest values of plant length, number of leaves/ plants, bulb diameter, fresh and dry weight of plant in both seasons and nick diameter in the 1st season. Planting small size cloves <1.5 g and medium size cloves (1.5-3.0g) gave the highest valued of bulbing ratio in the 1st season. However, planting small size cloves resulted in the lowest plant length, number of leaves, nick diameter (in the first season), bulb diameter, fresh and dry weight of plant in the two seasons.

With respect to the effect of nitrogen fertilizer levels treatments results indicate that there were significant differences between the different N treatments in growth parameters i.e., plant length, number of leaves/ plants, nick and bulb diameter and dry weight of plant (Tables 2 and 3). In this respect, 150 unit of N/fed treatment exhibited the highest values of plant length, number of leaves, bulb diameter, plant fresh and dry weight, as well as, nick diameter (in the 1st season only). Moreover, 90 unit of N/fed treatment exhibited the highest values of bulbing ratio in the two seasons. However, the lowest values of plant length, number of leaves/ plants, nick and bulb diameter, as well as fresh and dry weight of plant was noticed by the 90 unit of N/fed treatment.

Table (2). Effect of clove weight, nitrogen fertilization treatments and their interaction on vegetative growth of garlic plants in 2023/2024 (S1) and 2024/2025 (S2) seasons

Weight of Clove	N (K/fed.)	Plant length (cm)		Leaf number / plant		Neck diameter (cm)		Bulb diameter (cm)	
		S1	S2	S1	S2	S1	S2	S1	S2
<1.5g		62.33	87.83	6.78	7.72	1.20	1.43	2.13	2.27
1.5-3.0g		75.44	90.69	8.11	8.72	1.57	1.46	2.74	2.57
>3.0g		97.17	95.78	9.18	8.78	1.77	1.49	3.53	2.61
L.S.D. 5%		1.88	3.72	0.80	0.59	0.10	NS	0.05	NS
	90	74.00	87.81	7.41	7.78	1.47	1.40	2.52	2.27
	120	79.06	92.06	8.28	8.56	1.53	1.56	2.88	2.53
	150	81.89	94.44	8.39	8.89	1.53	1.42	3.02	2.65
L.S.D. 5%		1.31	2.41	0.63	0.68	0.06	0.07	0.10	0.15
<1.5g	90	58.00	84.67	6.00	6.83	1.20	1.37	1.70	1.85
	120	66.00	89.83	7.33	8.00	1.50	1.60	2.30	2.47
	150	63.00	89.00	7.00	8.33	0.90	1.32	2.40	2.50
1.5-3.0g	90	68.00	87.75	7.67	8.33	1.50	1.43	2.70	2.50
	120	75.00	89.00	8.33	8.67	1.40	1.50	2.73	2.57
	150	83.33	95.33	8.33	9.17	1.80	1.43	2.80	2.64
>3.0g	90	96.00	91.00	8.55	8.17	1.70	1.40	3.15	2.47
	120	96.17	97.33	9.17	9.00	1.70	1.57	3.60	2.55
	150	99.33	99.00	9.83	9.17	1.90	1.50	3.85	2.80
L.S.D. 5%		2.62	NS	NS	NS	0.13	0.17	0.15	0.26

Small (<1.5g), medium (1.5-3.0g), large (>3.0g)

Table (3). Effect of clove weight, nitrogen fertilization treatments and their interaction on vegetative growth of garlic plants in 2023/2024 (S1) and 2024/2025 (S2) seasons

Weight of Clove	N (K/fed.)	Bulbing ratio		Plant fresh weight (g)		Plant dry weight (g)	
		S1	S2	S1	S2	S1	S2
<1.5g		0.58	0.64	55.29	57.90	8.03	8.85
1.5-3.0g		0.57	0.57	65.12	70.33	9.61	9.93
>3.0g		0.50	0.57	82.38	79.38	10.67	10.93
L.S.D. 5%		0.04	NS	2.06	2.27	0.21	0.82
	90	0.60	0.63	63.23	66.24	8.40	9.33
	120	0.55	0.62	67.29	69.15	9.51	9.96
	150	0.50	0.54	72.27	72.21	10.39	10.41
L.S.D. 5%		0.05	0.06	0.89	1.95	0.35	0.43
<1.5g	90	0.71	0.75	52.03	56.30	6.60	8.15
	120	0.66	0.65	52.93	57.24	8.00	8.24
	150	0.37	0.53	60.90	60.14	9.49	10.15
1.5-3.0g	90	0.56	0.57	63.43	67.33	9.01	10.01
	120	0.52	0.59	65.94	70.82	9.54	10.05
	150	0.64	0.54	66.00	72.84	10.28	9.72
>3.0g	90	0.54	0.57	74.23	75.09	9.59	9.83
	120	0.47	0.62	82.99	79.39	11.00	11.58
	150	0.50	0.54	89.92	83.66	11.41	11.37
L.S.D. 5%		0.08	0.11	2.40	NS	0.53	1.01

Small (<1.5g), medium (1.5-3.0g), large (>3.0g)

Data in Tables 2 and 3 present the interaction between the weight of Clove and N fertilizer levels treatments showed significant effects on plant length in the 1st season, neck diameter, bulb diameter, bulbing ratio and fresh and dry weight of plant except plant length in the 2nd season, number of leaves in the two seasons. Planting the large size cloves with 150 unit of N/fed gave the highest plant length, neck diameter in the 1st seasons, bulb diameter, fresh weight of plant and dry weight of plant in the 1st seasons. Also, planting the large size cloves with 150 unit of N/fed and planting large size cloves with 120 unit of N/fed recorded the highest values of dry weight of plant in the first and second seasons, respectively. Furthermore, Planting the small size cloves (<1.5 g) with 90 unit of N/fed or 120 unit of N/fed recorded the highest values of bulbing ratio, in the first and second seasons. Conversely, planting the small size cloves with 90 unit of N/fed recorded the lowest plant length, number of leaves, bulb diameter, fresh and dry weight of plant in the two seasons. Moreover, planting the small size cloves g with 150 unit of N/fed or 90 unit of N/fed resulted in the lowest values of neck diameter in the first and second seasons. While planting with small size cloves with 150 unit of N/fed recorded the lowest values of bulbing ratio in the 1st and 2nd seasons.

2- Total yield and its components

The data presented in Tables 4 and 5 makes this evident between planting the weight of Clove (<1.5g, 1.5-3.0g and >3.0g) in total yield at harvest time, Total yield after curing, weight loss after curing percentage, bulb weight, neck diameter, bulb diameter. In this respect, the highest yield at harvest time of garlic plants, total yield after curing, and weight loss after curing percentage resulted from planting the large size cloves (>3.0 g), followed by planting medium size cloves (1.5-3.0 g) in the two seasons. On the contrary, the lowest values of the yield at harvest time of garlic plants, total yield after curing, and weight loss after curing percentage were obtained from planting small size cloves (<1.5 g) in both seasons. In the same respect, planting the large size cloves (>3.0 g) followed by planting medium size cloves (1.5-3.0 g) exhibited the greatest values of bulb weight, neck diameter, bulb diameter and bulb dry matter in the two seasons. On the other hand, bulbing ratio was not significantly affected by planting the weight of clove.

Table (4). Effect of clove weight, nitrogen fertilization treatments and their interaction on total yield and its components of garlic plants in 2023/2024 (S1) and 2024/2025 (S2) seasons

Weight of Clove	N (K/fed.)	Total yield at harvest (ton/fed.)		Total yield after curing (ton/fed.)		Weight loss after curing (%)	
		S1	S2	S1	S2	S1	S2
<1.5g		7.306	8.473	4.469	5.262	34.69	37.17
1.5-3.0g		10.640	11.165	7.164	7.769	47.83	47.36
>3.0g		11.669	11.278	8.405	7.888	53.06	51.00
L.S.D. 5%		0.208	0.091	0.071	0.085	1.03	1.51
	90	8.689	8.899	5.887	6.558	42.98	41.26
	120	9.611	10.477	6.526	6.975	44.61	44.78
	150	11.314	11.541	7.625	7.386	48.49	49.49
L.S.D. 5%		0.092	0.036	0.085	0.143	0.82	1.00
<1.5g	90	5.639	6.576	3.830	4.921	32.78	30.11
	120	6.703	8.778	4.256	5.027	33.83	38.17
	150	9.576	10.065	5.320	5.839	37.47	43.22
1.5-3.0g	90	9.789	9.597	6.384	7.067	45.50	45.17
	120	10.214	11.534	7.235	8.113	46.00	47.00
	150	11.917	12.364	7.874	8.126	52.00	49.92
>3.0g	90	10.640	10.523	7.448	7.687	50.67	48.50
	120	11.917	11.119	8.086	7.785	54.00	49.17
	150	12.449	12.193	9.682	8.193	56.00	55.33
L.S.D. 5%		0.244	0.104	0.139	0.218	1.54	2.05

Small (<1.5g), medium (1.5-3.0g), large (>3.0g)

The results displayed in Tables 4 and 5 show that The highest values of total yield at harvest time, total yield after curing, weight loss after curing percentage, bulb weight, neck diameter, bulb diameter in the both seasons were obtained from 150 unit of N/fed followed by 120 unit of N/fed in the 1st and 2nd seasons. While, the highest bulb dry matter was obtained from 90 unit of N/fed in the in the 2nd season. On the other hand, bulbing ratio was not significantly affected by nitrogen fertilizer levels treatments in the both seasons.

Tables 4 and 5 present the effect of the interaction between the size of planting clove size (<1.5g, 1.5-3.0g and >3.0g) treatments and the effect of nitrogen fertilizer levels treatments. Significant effects showed on total yield at harvest time, total yield after curing, weight loss after curing percentage, bulb weight, neck diameter, bulb diameter. Also, results indicate that, planting the large size cloves (>3.0 g) with 150 unit of N/fed and planting the medium size cloves (1.5-3.0 g) with 150 unit of N/fed gave the heights values of total yield at harvest time in the first and second seasons, respectively. Also, planting the large size cloves with 150 unit of N/fed gave the heights values of total yield after curing, weight loss after curing percentage, bulb weight in the 1st and 2nd seasons, and neck diameter, bulb diameter (in the second season). While, planting the medium size cloves (1.5-3.0g) with 120 unit of N/fed and planting the large size cloves 150 unit of N/fed gave the heights values of bulb dry matter in the 1st and 2nd seasons, respectively. While, the bulbing ratio demonstrates no significant differences attributable to the interactive effect between size of planted cloves and nitrogen fertilizer levels treatments in the 1st season.

Table (5). Effect of clove weight, nitrogen fertilization treatments and their interaction on garlic bulb quality after curing in 2023/2024 (S1) and 2024/2025 (S2) seasons

Weight of Clove	N (K/fed.)	Bulb weight (g)		Neck diameter (cm)		Bulb diameter (cm)		Bulbing ratio		Bulb dry matter%	
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
<1.5g		34.69	37.17	0.85	0.83	4.81	4.77	0.18	0.17	37.66	33.51
1.5-3.0g		47.83	47.36	0.91	0.97	5.43	5.23	0.17	0.19	39.19	34.66
>3.0g		53.56	51.00	0.94	1.05	5.56	5.29	0.17	0.20	39.35	34.69
L.S.D. 5%		1.03	1.51	0.05	0.14	0.11	0.12	N.S.	N.S.	0.92	0.97
	90	42.98	41.26	0.87	0.89	4.95	4.81	0.17	0.19	39.10	35.07
	120	44.61	44.78	0.91	0.98	5.31	5.11	0.17	0.19	38.68	33.73
	150	48.49	49.49	0.93	0.99	5.55	5.38	0.17	0.18	38.43	34.06
L.S.D. 5%		0.82	1.00	0.04	0.08	0.12	0.11	N.S.	N.S.	N.S.	0.62
<1.5g	90	32.78	30.11	0.79	0.76	4.41	4.42	0.18	0.17	38.27	34.52
	120	33.83	38.17	0.83	0.80	4.79	4.68	0.18	0.17	37.04	33.59
	150	37.47	43.22	0.92	0.94	5.23	5.22	0.18	0.18	37.68	32.42
1.5-3.0g	90	45.50	45.17	0.92	0.84	5.20	5.08	0.18	0.17	38.71	35.06
	120	46.00	47.00	0.96	1.19	5.55	5.17	0.17	0.23	40.40	34.92
	150	52.00	49.92	0.84	0.88	5.55	5.45	0.15	0.16	38.47	34.00
>3.0g	90	50.67	48.50	0.88	1.06	5.23	4.91	0.17	0.22	40.32	35.64
	120	54.00	49.17	0.93	0.96	5.58	5.48	0.17	0.17	38.59	32.68
	150	56.00	55.33	1.02	1.13	5.87	5.47	0.17	0.21	39.15	35.75
L.S.D. 5%		1.54	2.05	0.08	0.18	0.20	0.20	N.S.	0.04	1.20	1.30

Small (<1.5g), medium (1.5-3.0g), large (>3.0g)

3- Chemical constituents

The results displayed in Table 6 show significant differences between planting different sizes of cloves (<1.5g, 1.5-3.0g and >3.0g) in carbohydrates content, nitrogen, phosphorus, potassium crude protein in dry matter of the bulbs. However, planting the different weights of cloves had no significant effect on phosphorus percentage. Planting the large size cloves produced the highest carbohydrates content in both tested seasons. The lowest carbohydrates content in dry matter of garlic bulbs were noticed by planting the small size cloves and medium size cloves in the first and second seasons, respectively (Table 6). Planting the large size cloves produced the greatest level of N, K and crude protein in dry matter of garlic bulbs in both seasons. However, the lowest values of N, K and crude protein in dry matter of garlic bulbs were noticed by planting the small size cloves in both seasons. On the other hand, planting the small size cloves produced the highest pungency in two seasons (Figure 1). However, the lowest pungency was noticed by planting the medium size cloves in both seasons (Figure 1).

Regarding the influence of nitrogen fertilizer level treatments as shown in Table 6, the data indicate that carbohydrates content, N, P, K and crude protein in dry matter of the bulbs were significantly affected as a result of N treatments. The highest values of nitrogen, potassium and crude protein in dry matter of the bulbs in the both seasons were obtained from 150 unit of N/fed treatment in the first and second seasons. While the highest values of phosphorus were obtained in 120 unit of N/fed treatment followed by 150 unit of N/fed treatment in the 1st season only. However, the highest values of pungency were obtained from 90 unit of N/fed followed by 120 unit of N/fed treatment in the first and second seasons (Figure 2).

Table (6). Effect of clove weight, nitrogen fertilization treatments and their interaction on chemical content of garlic bulbs of garlic plants in 2023/2024 (S1) and 2024/2025 (S2) seasons

Weight of Clove	N (K/fed.)	Carbohydrates (g/100 g d.w.)		N (%)		P (%)		K (%)		Crude protein (%)	
		S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
<1.5g		42.84	43.58	1.07	1.09	0.26	0.28	1.61	1.57	6.66	6.81
1.5-3.0g		43.08	42.80	1.55	1.30	0.24	0.29	1.67	1.67	9.71	8.11
>3.0g		43.32	43.65	1.55	1.59	0.27	0.30	1.79	1.78	9.72	9.93
L.S.D. 5%		0.05	0.11	0.06	0.20	N.S.	N.S.	0.03	0.11	0.39	1.27
	90	41.31	42.03	1.19	1.19	0.23	0.28	1.70	1.65	7.44	7.41
	120	44.44	44.20	1.33	1.27	0.27	0.29	1.64	1.65	8.29	7.93
	150	43.50	43.80	1.66	1.52	0.26	0.29	1.73	1.72	10.36	9.50
L.S.D. 5%		0.20	0.19	0.04	0.12	0.03	N.S.	0.04	0.05	0.26	0.77
<1.5g	90	39.71	40.50	0.97	1.07	0.22	0.28	1.70	1.61	6.07	6.69
	120	44.63	44.63	0.95	1.04	0.28	0.28	1.52	1.61	5.96	6.49
	150	44.18	45.62	1.27	1.16	0.28	0.27	1.60	1.49	7.96	7.24
1.5-3.0g	90	41.22	41.35	1.25	1.10	0.22	0.29	1.77	1.67	7.82	6.85
	120	44.50	43.45	1.63	1.28	0.25	0.28	1.59	1.54	10.18	8.01
	150	43.52	43.58	1.78	1.51	0.25	0.31	1.66	1.80	11.14	9.47
>3.0g	90	42.99	44.24	1.35	1.39	0.26	0.28	1.63	1.66	8.44	8.70
	120	44.18	44.50	1.40	1.49	0.29	0.31	1.81	1.79	8.74	9.29
	150	42.80	42.21	1.92	1.89	0.26	0.30	1.92	1.88	11.97	11.80
L.S.D. 5%		0.28	0.29	0.09	N.S.	N.S.	N.S.	0.06	0.13	0.53	N.S.

Small (<1.5g), medium (1.5-3.0g), large (>3.0g)

The interaction between planting with different clove sizes (<1.5g, 1.5-3.0g and >3.0g) and the effect of nitrogen fertilizer levels treatments showed significant effects on carbohydrates content, nitrogen, phosphorus, crude protein in dry matter of the bulbs (Table 6 and Figure 3). Also, planting the large size cloves with 150 unit of N/fed treatment gave the heights values of nitrogen, potassium and crude protein in dry matter of the bulbs in the two seasons. On the other hand, phosphorus content was not significantly affected by the interaction between the weight of clove and nitrogen fertilizer levels treatments in the both seasons. Results indicate in Figure 3 that planting the small size cloves with 90 unit of N/fed treatment and planting the large size cloves with 120 unit of N/fed treatment gave the heights values of pungency in the first and second seasons, respectively.

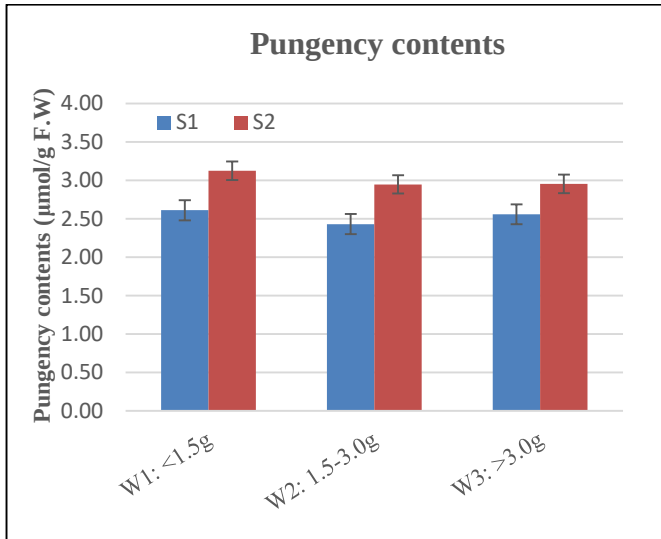


Fig. (1). Effect of clove weight on pungency contents of garlic bulbs in 2023/2024 (S1) and 2024/2025 (S2) seasons. Bar indicates LSD ($P \leq 0.05$)

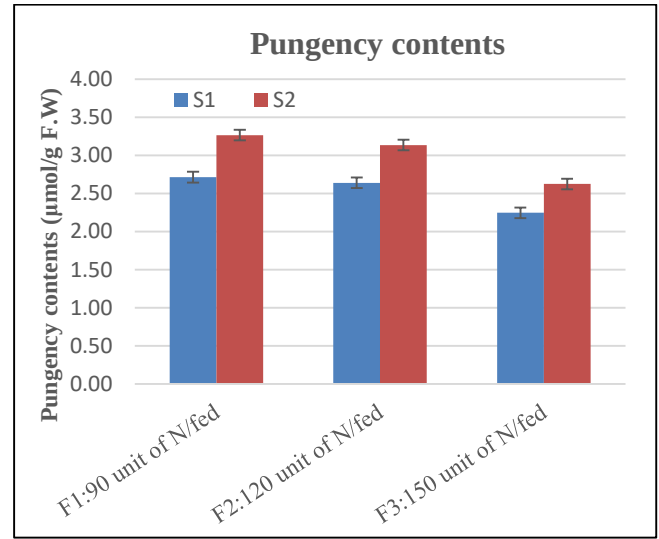


Fig. (2). Effect of nitrogen fertilization treatments on pungency contents of garlic bulbs in 2023/2024 (S1) and 2024/2025 (S2) seasons. Bar indicates LSD ($P \leq 0.05$)

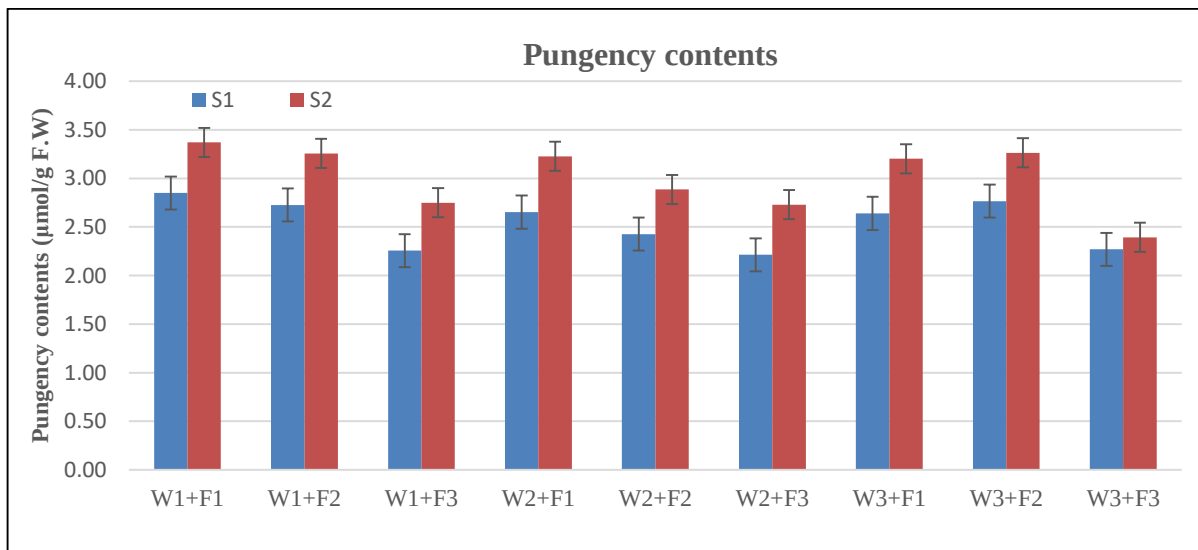


Fig. (3). Effect of the interaction between planting the weight of clove and the effect of nitrogen fertilizer levels treatments on pungency contents of garlic bulbs in 2023/2024 (S1) and 2024/2025 (S2) seasons. Bar indicates LSD ($P \leq 0.05$)

4. Discussion

The findings demonstrated that clove weight exerted a statistically significant influence on growth characteristics, yield and its components, and chemical content of garlic bulbs, with heavier large cloves planting materials yielding superior fresh produce and cured output compared to small size cloves and medium size cloves across both experimental seasons. Planting the weight large size cloves (>3.0g) exhibited the highest values of plant length, number of leaves/ plants, bulb diameter, fresh and dry weight of garlic plant of the trial and neck diameter in 1st season. Planting the small size cloves (<1.5 g) and medium size cloves (1.5-3.0g) gave the highest valued of bulbing ratio in the 1st season. The enhanced development of vegetative characteristics in garlic cultivars can be ascribed to the elevated concentration of nutritional reserves accumulated within the cloves employed for agricultural propagation, particularly during the early phases of plant establishment (**Deka and Shadeque 1993**). The use of large-sized garlic seeds in cultivation practices generates superior yields, albeit accompanied by elevated production costs relative to small-sized seeds, which produce lower yields at more economical expense levels. Therefore, an imperative need exists to implement standardized protocols regarding garlic seed dimensions utilized in propagation techniques, thereby enabling the attainment of results that demonstrate both cost-effectiveness and productive efficiency (**Castellanus et al. 2004**). **El-Mesirry and Radi (2019)** demonstrated that greater clove size of the separation, the greater for characteristics of vegetative growth, yield, and components. Also, **Ibrahim et al. (2020)** indicated that the heavy (3.5 – 4 g) and medium (2 - 2.5 g) cloves weight produced the highest vegetative growth, clove weight, and total yield. Also, the obtained result is in harmony with the finding of **Albaba et al. (2020)**, **Desta et al. (2021)** demonstrated that increasing the planting of cloves size enhance vegetative growth and total bulb yield of garlic planting.

The nitrogen level increased growth parameters i.e., plant length, number of leaves/ plants, neck and bulb diameter, fresh and dry weight of plant up to the highest nitrogen level, i.e., 150 unit of N/fed (Table 2 and 3). The enhancement of plant growth through elevated nitrogen concentrations may be attributed to nitrogen's fundamental involvement in photosynthetic processes, protein biosynthesis, cellular division, and cellular expansion all of which constitute the foundational mechanisms underlying plant development. Furthermore, nitrogen serves a critical function in enzymatic activity, which reflects more products needed in plant growth. In this respect obtained results are in agreement with those mentioned by **Ahmed et al. (2012)**, **Hassan (2015)**, **Taha et al. (2024)**. Also, **Samy and El-Zohiri, (2021)** showed that increasing nitrogen fertilizer up to 150% N of the recommended rate improved growth traits (plant length, number of leaves, fresh and dry weight of plant, bulb characters, chemical constituents, yield, and yield components). Also, **Kevlani, et al. (2023)** indicated that N had positively affected the growth and bulb yield of garlic plants. In the same line, **Shafeek et al (2021)** and **Mansour et al. (2024)** reported that the addition of the highest level of N fertilizers (120 kg N/fed.) improved plant growth, yield, physical and chemical characters of garlic plants.

The interaction between the weight of Clove and N fertilizer levels treatments showed significant effects on vegetative growth measurements, yield and its components, and Chemical content of garlic bulbs. Planting the weight of large size cloves (>3.0g) with 150 unit of N/fed treatment gave the highest values of plant length, neck diameter, bulb diameter, plant fresh weight, plant dry weight of plant, total yield at harvest time, total yield after curing, weight loss after curing (%), bulb weight, neck diameter, bulb diameter, nitrogen, potassium and crude protein in dry matter of the bulbs. On the other hand, obtained results indicated that planting the small size cloves (<1.5g) with 90 unit of N/fed and planting the large size cloves (>3.0g) with 120 unit of N/fed treatment gave the heights values of pungency. These results are in agreement with those obtained by **Rahman et al. (2004)** they report that the treatment combination of large sized clove and 150 kg N/ha produced the highest yield. The positive outcomes are primarily attributed to the strong interaction between the weight of clove and N fertilizer, which plays a vital role; may be attributed to the increase in nutrients stored in the cloves used in planting, especially in the initial growth stages and nitrogen's fundamental involvement all the foundational mechanisms underlying plant development.

5. Conclusion

The present study clearly demonstrates that planting the large size cloves(>3.0 g) or medium size cloves (1.5-3.0 g) , either alone or in combination with the treatment of N fertilizer applied at 150 unit of N/fed, significantly improved vegetative growth, yield and its components, bulb quality and chemical composition of Balady garlic bulbs. The combined treatments, produced the most consistent and superior results across most parameters during the two growing seasons.

Conflicts of interest

The authors declare that there are no conflicts of interest.

Author contribution

Each author authorized the final article for publication and made an equal contribution to this study.

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