Journal of Plant Production

Journal homepage & Available online at: www.jpp.journals.ekb.eg

Impact of Intercropping Coriander-Garlic System and Nitrogen Fertilizer Rate on Growth, Productivity and Competitive Indices of Both Components

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Article Information
Received14 /7 /2025
Accepted 6/ 9/2025

ABSTRACT

This work was carried out in the experimental Farm of the Faculty of Environmental Agricultural Sciences, Arish University, North Sinai, Egypt, during the two consecutive winter seasons of 2022/2023 and 2023/2024 to study the impact of different nitrogen fertilizer rates (0.0, 30, 50 and 70 kg N/ feddan), different intercropping systems (sole planting of each component as control, 1: 1, 2: 2 and 2: 3 as row ratio of coriander: garlic, respectively) and their combination treatments on growth traits, yield components and some competitive indices between the two components. The obtained results cleared that the highest values of growth for coriander and garlic, their yield components, the percentages of total carbohydrates and nitrogen was observed when coriander was intercropped with garlic at a row ratio of 2: 3 in comparison with sole crop and the other intercropping systems under study. In contrast to the other nitrogen rates being investigated, applying nitrogen as a soil application at the highest rate (70 kg N /feddan) resulted in a heaviest yield of garlic bulbs per feddan and coriander fruits per plant and feddan. The study concluded that the optimal combination treatment based on competitive indices analysis was the 1.361 and 1.356 land equivalent ratio, the 1.322 and 1.315 area × time equivalent ratio and the 134.11 and 133.55 % land utilization efficiency, was the treatment of 2: 2 intercropping system in combination with 70 kg N /feddan rate. Also, aggressivity estimation showed that coriander was dominant while garlic was dominated.

Keywords: Coriander, garlic, intercropping, nitrogen, growth, yield, LER, ATER, LUE

INTRODUCTION

The coriander plant (*Coriandrum sativum*, L.), a member of the *Apiaceae* family, is an annual herbaceous plant that is native to the Mediterranean region but is widely grown for culinary purposes in Central Europe, North Africa, Asia, and Egypt (Mhemdi *et al*., 2011). The top 20 essential oil plants at one point included coriander (Lawrence, 1993). While its fragile green leaves are utilized as culinary herbs, dried fruits are pulverized and frequently employed as a flavouring agent in food goods, condiments or spices. According to Statistics of the Ministry of Agriculture (2024), the total area cultivation of dry coriander in Egypt in 2023/2024 was 5,137 feddan (1449 feddan in new reclaimed land and 3.868 feddan in old agricultural land). Produced 5.048 tons (728 tons from new reclaimed land and 4.318 tons from old agricultural land) with an average of 0.949 tons/feddan (0.502 tons/feddan in new reclaimed land and 1.116 tons /feddan in old agricultural land).

Garlic (*Allium sativum* L.) which belongs to family *Alliaceae* is one of the oldest vegetable crops under cultivation in the world. A secondary use for garlic is as a medication for conditions including coronary heart disease and high cholesterol (Sulichantini, 2016). Nainwal *et al*. (2015) stated that garlic is the plant in the onion family that is most widely farmed. Cloves of garlic are frequently used as a condiment or spices (they contain allicin in the form of allyl sulphide) and for a variety of medical conditions (El-Hifny, 2010). According to Statistics of the Ministry of Agriculture (2024), the total area under cultivation of sole garlic in Egypt in 2023/2024 was 53,921 feddan (15,903 feddan in new reclaimed land and 38.018 feddan in old agricultural land), produced 563,887 tons (158,356 tons from new reclaimed land and 405,531 tons from old agricultural land) with an average of 10.458 tons/feddan (9.958 tons/ feddan in new reclaimed land and 10.688 tons /feddan in old agricultural land). Whereas, the total area under cultivation of intercropped garlic in Egypt in 2023/2024 was 686 feddan (140 feddan in new reclaimed land and 546 feddan in old agricultural land). Produced 4,907 tons (693 tons from new reclaimed land and 4,214 tons from old agricultural land) with an average of 6.266 tons/feddan (5.112 tons/feddan in new reclaimed land and 6.266 tons /feddan in old agricultural land).

Compared to growing a single crop, intercropping can boost agricultural yields more (Mandal *et al*., 1986). A key component of agricultural sustainability, intercropping is a sustainable practice that is employed in both developed and developing nations (Maffei and Mucciarelli, 2003). To improve environmental conditions and resource usage, intercropping has a significant role in increasing the productivity and stability of yield components (Alizadeh *et al*., 2010). Moreover, Alternating 2 rows of caraway with 1 row of garlic significantly increased land equivalent ratio, area× time equivalent ratio and land utilization efficiency compared to the other intercropping systems (1: 2 and 2: 2 systems) under study (Khashaba *et al*., 2023 b).

Since nitrogen is regarded as a crucial nutrient in the development of crops, it is a necessary component for plant growth and maintenance (Marschner, 1995). In addition, garlic productivity and growth are greatly impacted by nitrogen fertilizer (Ewais *et al*., 2016). It is an essential component of chlorophyll, which facilitates photosynthesis, and is a vital nutrient for vegetative growth, especially the development of leaves and stems. A deeper green hue, bigger leaves, and increased plant vigor are all benefits of adequate nitrogen. Also, Alaei *et al.* (2024) reported that N fertilizer improved the growth, yield and quality of coriander fruits.

The aim of this study was to assess the influences of intercropping system, nitrogen fertilizer rate and their combination treatments on growth and yield components, Total carbohydrates and nitrogen percentages as well as some

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DOI: 10.21608/jpp.2025.403979.1489

competitive indices of coriander and garlic plants under North Sinai Governorate conditions.

MATERIALS AND METHODS

This work was carried out at the experimental farm of the Faculty of Environmental Agricultural Sciences, Arish University, North Sinai, Egypt, during the two consecutive winter seasons of 2022/2023 and 2023/2024 to study the influence of different intercropping systems, different nitrogen fertilizer rates and their combination treatments on growth traits, yield components, some chemical constituents and competitive indices of coriander and garlic crops. The mechanical as well as chemical properties of experimental soil was utilized are gave in Table 1 according to Chapman and Pratt (1978).

Table 1. Mechanical and chemical properties of experimental soil

Mechanical analysis										Soil texture
Clay (%)			Silt (%)				Sand (%)			Clay
58.23			27.58				14.19			
Chemical analysis										
pH	E.C. dSm^{-1}	Organic matter (%)	$CaCO_3$ (%)	Soluble cations(meq./ L)				Soluble anions(meq. /L)		
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{--}
8.03	2.28	0.64	0.47	11.89	10.34	3.20	5.14	8.93	5.58	16.06
Available nutrient (mg kg^{-1}soil)										
N		P	K	Fe			Zn	Cu		Mn
37.25		24.31	197	1.67			0.62	0.53		0.47

Cultivation:

The experimental unit area was 56 m^2 (4 m × 14.00 m) contained 20 ridges 70 cm apart and 30 cm between coriander plants (two plants/hill) sown in two sides of ridge and 10 cm between garlic (plant /hill) plants sown in both sides of ridge. Therefore, the number of coriander plants in a feddan (4000 m^2) for sole crop was about 38096 plants/ feddan as well as the number of garlic plants was 114,286 plants/ feddan.

This experiment included 16 treatments, which were the combinations between four intercropping systems and four nitrogen fertilizer rates which were; Control (without nitrogen fertilizing), 30, 50 and 70 kg N/ feddan which added to the soil at 40, 70 and 100 days after sowing date. The intercropping system treatments were as follows:

1. Sole planting system of coriander as well as garlic, since coriander was practice on both sides of the ridge, it sowed at 30 cm distance apart and two plant/hill. Such treatment was used as control for coriander characters. Garlic was applied on both sides of the ridge, at 10 cm distance apart. Such treatment was used as control for garlic traits.
2. Intercropping system of 1:1; since planting 1 ridge of coriander alternated with 1 ridge of garlic (1 ridge of coriander: 1 ridge of garlic). Such system provides the proportional area of 50.0: 50.0 to each of coriander and garlic, respectively.
3. Intercropping system of 2: 2; since planting 2 ridges of coriander alternated with 2 ridges of garlic (2 ridges of coriander: 2 ridges of garlic). Such system provides the proportional area of 50.0: 50.0 to each of coriander and garlic, respectively.
4. Intercropping system of 2: 3; since planting 2 ridges of coriander alternated with 3 ridges of garlic (2 ridges of coriander: 3 ridges of garlic). Such system provides the proportional area of 40.0: 60.0 to each of coriander and garlic, respectively.

All the plants of both crops (coriander & garlic) received normal agricultural practices whenever they needed. Fertilizers of phosphorus and potassium were added during soil preparation as a soil application at the rate of 200 kg/feddan of calcium super phosphate (15.5% P_2O_5) and 50 kg/feddan of potassium sulphate (50% K_2O), respectively. While, nitrogen fertilizer at the different rates under study as ammonium sulfate (20.5% N) which was divided into three equal portions and added to the soil at 30, 70 and 100 days after sowing.

Recorded Data:

Growth and yield traits:

After 115 days from sowing date the following data were recorded: plant height (cm), and total dry weight /plant (g) of coriander and garlic. While, number of umbels/plant, fruit yield/plant (g) and /feddan (kg) were determined after 204 days from sowing of coriander fruits as well as bulb diameter, number of cloves per bulb and bulb yield per feddan (ton) were recorded after 190 days from sowing of garlic cloves. In addition, total nitrogen and total carbohydrates percentages in fruits of coriander and cloves of garlic were determined according to Chapman and Pratt (1978) and Dubois *et al.*, (1956) respectively.

Competitive indices:

1. Land equivalent ratio (LER):

This indicates the proportion of land needed for a sole crop in order to yield the same amount of crop as an intercropping arrangement. The crucial value is the value of togetherness. Intercropping promotes the growth and yield of the constituents when the LER is higher than one. The yield of coriander and garlic per feddan was calculated using the following equation:

$$\mathbf{LER = Lc + Lg}$$

$$\mathbf{Lg} = \frac{\mathbf{Ycg}}{\mathbf{Ygg}} \quad \mathbf{Lc} = \frac{\mathbf{Ycg}}{\mathbf{Ycc}}$$

Where, Ycc and Ygg are the yields per feddan of coriander and garlic, respectively, as sole crops, Ycg, and Ygc are the yields of coriander and garlic, respectively, as intercrops (Mead and Willey, 1980).

2. Area time equivalent ratio (ATER):

It was calculated according to the following equation:

$$\mathrm{ATER} = \frac{Ygc/\ Ygg \times t\,g\ + Ycg\ /\ Ycc \times t\,c}{T}$$

Where: Ycc = Sole yield of coriander, Ygg = Sole yield of garlic, Ycg = Intercrop yield of coriander, Ygc= Intercrop yield of garlic, tc = The duration of coriander in days (204 days), tg = The duration period of garlic in days (190 days) and T = The total duration of intercropping system in days (Hiebesch and Mc Collum, 1987).

3. Land utilization efficiency (LUE):

By utilizing ATER and LER values, the land utilization efficiency percentage (LUE %) was calculated according to (Mason *et al.*, 1986) equation as follows:

$$\mathrm{LUE\ \%} = \frac{\mathrm{LER + ATER}}{2} \times 100$$

4. Competitive ratio (CR):

Another method for estimating competition between different species is CR. According to Willey and Rao (1980), the CR provides a more accurate assessment of the crops' capacity for competition and has advantages over as an index. The proportion of the crops in which they are initially sown is taken into account by the CR, which frugally depicts the ratio of individual LERs of the two component plants. The formula below is used to determine the CR:

$$\text{CR coriander} \times \text{garlic} = \frac{\text{LER coriander}}{\text{LER garlic}} \left(\frac{\text{Zgc}}{\text{Zcg}}\right)$$

$$\text{CR garlic} \times \text{coriander} = \frac{\text{LER garlic}}{\text{LER coriander}} \left(\frac{\text{Zcg}}{\text{Zgc}}\right)$$

5. Aggressivity (A).

Aggressivity value was calculated according to Mc Gilchrist (1965) equation as follows:For 50: 50 or 100: 100 row ratio:

Acg = Lc –Lg & Agc = Lg – Lc

For another row ratio:

$$Acg = \frac{Ycg}{Ycc \times Zcg} - \frac{Ygc}{Ygg \times Zgc}$$

$$Agc = \frac{Ygc}{Ygg \times Zgc} - \frac{Ycg}{Ycc \times Zcg}$$

Where:

Ycc = Coriander sole yield;
Ygg = Garlic sole yield;
Ycg = Coriander intercrop yield;
Ygc = Garlic intercrop yield;
Zcg = Coriander sowing proportion.
Zgc = Garlic sowing proportion and

Experimental Design and Statistical Analysis:

The statistical layout of this experiment was split-plot design. Since the 1st factor was intercropping systems which contained four treatments, while the 2nd factor was nitrogen fertilizer rates included four treatments. Each treatment included three replicates. Each replicate contained twenty rows. The recoded data were statistically analyzed, and the means were compared using statistix software version 9 (Analytical software, 2008).

RESULTS AND DISCUSSION

Influence of intercropping system, nitrogen fertilizer rate and their combinations on growth, yield components and chemical constituents of coriander plants:

The results in Table 2 show that all intercropping systems recorded significant increases in plant height and total dry weight of coriander, when comparing to the sole crop in both seasons. Additionally, the highest values of the coriander yield components (umbels number per plant, fruit yield per plant) were obtained utilizing the 2:3 system in comparison to the other systems under study (Table 3). In contrast, when compared to the intercropping systems under study in both seasons, the coriander sole crop yielded the highest fruit per feddan (697.87 and 725.35 kg/feddan, respectively). Moreover, during the two growing seasons, alternating 2 rows of coriander with 3 rows of garlic gave a significant enhance of volatile oil, total carbohydrates and total nitrogen percentages in coriander fruits compared to the other intercropping systems under study (Table 4). The compatibility of the imported crops, as well as the availability and management of nutrients, all affect the growth and productivity of coriander.

Table 2. Influence of intercropping system (A), nitrogen fertilizer rate (B) and their combinations on growth traits of coriander plant during the two seasons

Treatments		Plant height (cm)		Total dry weight of plant (g)	
		1st season	2nd season	1st season	2nd season
Intercropping system (coriander: garlic as row ratio)					
Sole coriander		111.13	107.88	41.48	39.86
1: 1		112.13	114.88	44.18	41.92
2: 2		116.63	117.88	46.99	44.95
2: 3		120.62	119.88	46.47	47.59
LSD 5%		3.72	2.96	0.65	0.99
Nitrogen fertilizer rate (N kg/feddan)					
Control		107.88	109.50	42.01	40.19
30		114.63	113.50	43.40	42.50
50		117.38	116.50	46.17	44.96
70		120.63	121.00	47.55	44.67
LSD 5%		1.15	1.93	0.63	0.64
Combination between intercropping system and nitrogen fertilizer rate					
Sole coriander	Control	103.50	103.00	40.59	37.92
	30	113.00	106.50	41.09	39.77
	50	113.50	109.00	41.69	40.82
	70	114.50	113.00	52.54	40.92
1 : 1	Control	104.50	107.50	41.32	38.14
	30	109.50	115.00	42.42	40.84
	50	115.00	117.00	45.87	43.19
	70	119.50	120.00	47.12	45.49
2 : 2	Control	111.50	111.50	42.79	41.32
	30	114.50	115.50	45.04	42.92
	50	118.50	119.00	49.24	46.42
	70	122.00	125.50	50.89	49.12
2 : 3	Control	112.00	116.00	43.33	43.36
	30	121.50	117.00	45.03	46.46
	50	122.50	121.00	47.88	49.41
	70	126.50	125.50	49.64	51.14
LSD 5%		4.16	4.39	1.26	1.46

Likewise, Khashaba *et al*. (2023 a) demonstrated that alternating 2 rows of caraway with 2 rows of garlic produced the highest plant height, number of branches per plant and plant fresh weight values of caraway plants compared to sole caraway. These results are in line with those reported by Abdelkader *et al.* (2018) on caraway intercropped with onion, Yousif *et al.* (2023) on coriander intercropped with garlic and Baruah *et al.* (2025) on coriander intercropped with chickpea.

The data illustrated in Table 2 reveal that using any nitrogen fertilization rate (30, 50 or 70 kg N /feddan) significantly increased coriander growth traits in comparison with control in both seasons. Furthermore, the highest values in number of umbels per plant, fruit yield per plant and per feddan were obtained from 70 kg N/ feddan (Table 3). Moreover, this rate (70 kg N/ feddan) recorded the highest volatile oil percentage (0.91 and 0.88 %), total carbohydrates percentage (18.49 and 18.09 %) and total nitrogen percentage (2.47 and 2.46 %) if coriander in the 1st and 2nd seasons, respectively (Table 4). Nitrogen has several processes in plant development. It is a serious protoplasm enzyme constituent, the biological catalytic agent which speed up plant life growth. N is present in alkaloids, chlorophyll phosphatides, glycosides and many other plant cell organic substances (Vopyan, 1984). These results are in harmony with those found by Carrubba (2009) and Alaei et al. (2024) on coriander plants.

According to the results in to Table 2 it is clear that, all combination treatment between intercropping systems and nitrogen fertilizer rates recorded the highest values of coriander growth traits as compared to the other treatments under study. Moreover, fertilized coriander plants with nitrogen at 70 kg N /feddan combined with 2: 2 or 2: 3 systems were the superior and significantly increased plant height and total dry weight of coriander compared to the other combination under study in both seasons. Also, under two rows of coriander, increase garlic rows number from 2 to 3, the growth traits of coriander plant was increased in both seasons. Alternating 2 rows of coriander with 3 rows of garlic combined with 70 kg N/feddan produced the highest values of number of umbels per plant and fruit yield per plant compared to the other combinations under study (Table 3). Sole crop of coriander combined with the high rate of nitrogen gave the highest fruit yield per feddan. The highest values of total nitrogen percentage was noticed when coriander was intercropped with garlic at 2: 2 system plus 70 kg N / feddan (Table 4).

Table 3. Influence of intercropping system (A), nitrogen fertilizer rate (B) and their combinations on yield components of coriander plant during the two seasons

Treatments		Number of umbels / plant		Fruit yield / plant(g)		Fruit yield / feddan (kg)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
Intercropping system (coriander: garlic as row ratio)							
Sole coriander		72.75	71.88	18.32	19.04	697.87	725.35
1: 1		74.25	85.63	24.95	25.03	475.15	476.82
2: 2		81.88	86.38	28.21	28.31	537.25	539.20
2: 3		82.63	91.25	29.78	29.10	453.78	443.42
LSD 5%		1.97	2.17	0.14	0.43	4.63	7.14
Nitrogen fertilizer rate (N kg/feddan)							
Control		73.13	78.75	23.39	23.38	497.42	501.21
30		76.63	81.75	24.86	24.74	530.47	536.88
50		80.75	85.63	26.33	26.44	565.57	568.75
70		81.00	89.00	26.68	26.93	570.59	577.94
LSD 5%		1.31	1.07	0.31	0.22	7.95	4.09
Combination between intercropping system and nitrogen fertilizer rate							
Sole coriander	Control	66.50	63.50	16.58	17.12	631.44	652.20
	30	71.00	67.50	17.85	19.32	680.01	736.02
	50	76.00	74.00	19.55	19.83	744.78	755.25
	70	77.50	82.50	19.30	19.90	735.25	757.92
1 : 1	Control	69.00	82.50	22.87	23.17	435.63	441.34
	30	73.50	84.50	24.82	24.82	472.77	472.77
	50	77.50	87.00	25.92	25.87	493. 72	492.77
	70	77.00	88.50	26.17	26.27	498.49	500.39
2 : 2	Control	78.50	81.50	25.78	26.37	491.06	502.30
	30	80.00	85.50	27.38	27.17	521.53	517.53
	50	85.00	88.00	29.33	29.37	558.68	559.44
	70	84.00	90.50	30.33	30.32	577.73	577.54
2 : 3	Control	78.50	87.50	28.32	26.84	431.57	409.01
	30	82.00	89.50	29.37	27.64	447.57	421.21
	50	84.50	93.50	30.52	30.68	465.09	467.53
	70	85.50	94.50	30.90	31.23	470.89	475.91
LSD 5%		2.96	2.81	0.55	0.56	14.46	9.88

Table 4. Influence of intercropping system (A), nitrogen fertilizer rate (B) and their combinations on some chemical constituents of coriander plant during the two seasons

Treatments		Volatile oil (%)		Total carbohydrates (%)		Total nitrogen (%)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
Intercropping system (coriander: garlic as row ratio)							
Sole coriander		0.75	0.77	16.89	16.56	2.32	2.32
1: 1		0.84	0.80	17.30	17.62	2.40	2.38
2: 2		0.90	0.88	18.13	17.83	2.52	2.49
2: 3		0.93	0.89	18.97	17.64	2.51	2.48
LSD 5%		0.04	0.02	0.19	0.14	0.01	0.02
Nitrogen fertilizer rate (N kg/feddan)							
Control		0.78	0.78	17.11	16.67	2.40	2.36
30		0.85	0.82	17.48	17.16	2.43	2.41
50		0.88	0.86	18.21	17.74	2.45	2.44
70		0.91	0.88	18.49	18.09	2.47	2.46
LSD 5%		0.02	0.01	0.15	0.12	0.01	0.01
Combination between intercropping system and nitrogen fertilizer rate2.							
Sole coriander	Control	0.71	0.75	15.91	15.82	2.31	2.24
	30	0.75	0.76	16.46	16.22	2.32	2.34
	50	0.76	0.78	17.26	16.92	2.32	2.36
	70	0.78	0.80	17.91	17.27	2.34	2.35
1 : 1	Control	0.76	0.75	16.41	16.77	2.38	2.34
	30	0.84	0.77	16.76	17.72	2.39	2.36
	50	0.87	0.83	17.96	17.87	2.42	2.39
	70	0.90	0.87	18.06	18.12	2.43	2.42
2 : 2	Control	0.81	0.83	17.57	16.87	2.47	2.45
	30	0.88	0.87	17.92	17.27	2.50	2.48
	50	0.95	0.91	18.42	18.32	2.54	2.51
	70	0.97	0.94	18.62	18.87	2.57	2.54
2 : 3	Control	0.86	0.82	18.56	17.23	2.47	2.43
	30	0.93	0.88	18.76	17.43	2.52	2.47
	50	0.95	0.91	19.21	17.83	2.53	2.51
	70	0.98	0.94	19.36	18.08	2.55	2.53
LSD 5%		0.05	0.03	0.31	0.25	0.02	0.02

Moreover, Hamad (2017) reported that the highest values of fennel growth parameters (plant height and total dry weight per plant) as well as umbels number /plant, fruit yield/plant and per feddan and volatile oil yield/plant) were noticed when fennel plants were intercropped with fenugreek at 1:3 system and fertilized with nitrogen fertilizer at the

highest level (40 kg N/ feddan). These results are also in accordance with those noticed by Zen El-Dein (2015), Sheha *et al.* (2016) and Yildirim *et al.* (2020).

Influence of intercropping system, nitrogen fertilizer rate and their combinations on growth, yield components and chemical constituents of garlic plants:

In addition, Tables 5, 6 and 7 shows that the 2: 3 intercropping system significantly improved the garlic height and plant dry weight compared to sole planting and the other systems studied. In the 1st and 2nd seasons, when compared to the intercropping systems under study, the garlic sole crop produced the highest bulbs yield per feddan (6.54 and 6.44 tons/feddan, respectively). The more cloves number per bulb (25.50 and 24.50 cloves/bulb) and heaviest average bulb weight (65.50 and 68.31 g) of garlic were obtained under 2: 2 intercropping system compared to sole planting and the other ones under study in both seasons. The increase in total N and total carbohydrates percentages by intercropping systems could be attributed to the effective utilize of inputs like nutrients, water, light and energy, which can significantly enhance garlic bulbs yield.

Table 5. Influence of intercropping system (A), nitrogen fertilizer rate (B) and their combinations on growth traits of garlic plant during the two seasons

Treatments		Plant height (cm)		Total dry weight of plant (g)	
		1st season	2nd season	1st season	2nd season
Intercropping system (coriander: garlic as row ratio)					
Sole garlic		77.79	72.21	16.74	15.39
1: 1		81.41	77.90	17.31	16.73
2: 2		84.53	83.96	22.63	21.09
2: 3		87.23	86.98	19.80	19.88
LSD 5%		1.46	0.45	0.66	0.20
Nitrogen fertilizer rate (N kg/feddan)					
Control		79.46	75.51	17.44	17.23
30		81.41	79.20	18.50	17.56
50		84.00	81.40	19.96	18.88
70		86.08	84.94	20.58	19.41
LSD 5%		1.82	0.86	0.67	0.65
Combination between intercropping system and nitrogen fertilizer rate					
Sole garlic	Control	75.70	69.35	15.55	14.35
	30	76.65	69.60	16.50	14.70
	50	78.35	70.55	17.15	15.85
	70	80.45	79.35	17.75	16.65
1 : 1	Control	78.35	73.80	16.10	16.15
	30	79.70	76.95	16.15	15.40
	50	82.85	79.10	18.25	17.35
	70	84.75	81.75	18.75	18.00
2 : 2	Control	80.90	77.35	19.45	19.05
	30	84.00	84.10	21.75	20.50
	50	85.15	86.45	24.25	22.45
	70	88.05	87.95	25.05	22.35
2 : 3	Control	82.90	81.55	18.65	19.35
	30	85.30	86.15	19.60	19.65
	50	89.65	89.50	20.20	19.85
	70	91.05	90.70	20.75	20.65
LSD 5%		3.45	1.55	1.32	1.14

Table 6. Influence of intercropping system (A), nitrogen fertilizer rate (B) and their combinations on yield components of garlic plant during the two seasons

Treatments		Number of cloves / bulb		Average of bulb weight (g)		Bulbs yield / feddan (ton)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
Intercropping system (coriander: garlic as row ratio)							
Sole garlic		18.25	20.75	57.24	56.33	6.54	6.44
1: 1		21.88	22.25	60.88	60.01	3.48	3.43
2: 2		25.50	24.50	65.60	68.31	3.75	3.90
2: 3		21.00	21.75	54.98	54.10	3.77	3.71
LSD 5%		1.80	1.95	0.40	0.55	0.03	0.02
Nitrogen fertilizer rate (N kg/feddan)							
Control		18.00	18.63	56.31	56.55	4.13	4.13
30		20.50	21.75	58.41	58.56	4.29	4.28
50		22.75	23.50	61.09	60.84	4.49	4.46
70		25.38	25.38	62.88	62.80	4.62	4.61
LSD 5%		1.13	1.04	0.44	0.63	0.03	0.04
Combination between intercropping system and nitrogen fertilizer rate							
Sole garlic	Control	16.50	17.50	53.25	53.15	6.09	6.07
	30	17.50	20.00	56.35	54.55	6.44	6.23
	50	18.50	22.50	59.05	57.65	6.75	6.59
	70	20.50	23.00	60.30	59.95	6.89	6.85
1 : 1	Control	18.50	18.50	58.80	57.70	3.36	3.30
	30	20.00	21.50	59.80	59.40	3.42	3.39
	50	23.50	23.50	62.15	60.75	3.55	3.47
	70	25.50	25.50	62.75	62.20	3.59	3.55
2 : 2	Control	21.50	21.50	61.55	65.10	3.52	3.72
	30	25.50	24.50	64.35	67.45	3.68	3.85
	50	26.50	24.50	67.15	69.50	3.84	3.97
	70	28.50	27.50	69.35	71.20	3.96	4.07
2 : 3	Control	15.50	17.00	51.65	50.25	3.54	3.45
	30	19.00	21.00	53.15	52.85	3.64	3.62
	50	22.50	23.50	56.00	55.45	3.84	3.80
	70	27.00	25.50	59.10	57.85	4.05	3.97
LSD 5%		2.61	2.61	0.86	1.21	0.06	0.08

Table 7. Influence of intercropping system (A), nitrogen fertilizer rate (B) and their combinations on some chemical constituents of garlic plant during the two seasons

Treatments		Total carbohydrates (%)		Total nitrogen (%)	
		1st season	2nd season	1st season	2nd season
Intercropping system (coriander: garlic as row ratio)					
Sole garlic		26.59	25.83	2.73	2.82
1: 1		27.20	27.55	2.87	3.00
2: 2		28.74	28.33	3.28	3.14
2: 3		29.25	28.90	2.77	2.99
LSD 5%		0.90	0.64	0.19	0.23
Nitrogen fertilizer rate (N kg/feddan)					
Control		27.08	26.55	2.81	2.72
30		27.64	27.48	2.82	2.89
50		28.39	28.00	2.90	3.13
70		28.68	28.56	3.13	3.21
LSD 5%		0.36	0.35	0.09	0.09
Combination between intercropping system and nitrogen fertilizer rate					
Sole garlic	Control	26.05	24.95	2.63	2.71
	30	26.36	25.70	2.73	2.81
	50	26.90	26.25	2.73	2.81
	70	27.05	26.40	2.83	2.96
1 : 1	Control	26.20	25.65	2.83	2.69
	30	26.95	27.95	2.72	2.84
	50	27.70	28.20	2.82	3.19
	70	27.95	28.40	3.12	3.29
2 : 2	Control	27.65	27.55	3.12	2.77
	30	28.50	28.05	3.27	3.08
	50	29.25	28.25	3.32	3.36
	70	29.55	29.45	3.40	3.35
2 : 3	Control	28.40	28.05	2.65	2.72
	30	28.75	28.25	2.56	2.82
	50	29.70	29.30	2.71	3.18
	70	30.15	30.00	3.17	3.22
LSD 5%		1.07	0.87	0.24	0.28

The same study by Abdelkader *et al.* (2018) on caraway and onion intercropped demonstrated that using a 1:2 system - alternating 1 row of caraway with 2 rows of onion - significantly enhanced the onion bulb parameters in comparison to growing onion as a sole crop. These results are in accordance with those reported by Zyada (2016) when intercropped okra with cowpea, Baghdadi *et al.* (2018) on corn intercropped with soybean and Ali *et al.* (2024) on garlic intercropped with ryegrass.

Regarding the influence of nitrogen fertilizer rate on garlic growth (plant height and plant dry weight), yield components (number of cloves per bulb, average of bulb weight and bulbs yield per feddan) and some chemical constituents (total nitrogen and total carbohydrates percentages) of garlic crop, Tables (5, 6 and 7) shows that all nitrogen fertilization rates recorded a significant increase concern plant growth and productivity compared to control during both seasons. Where, increasing nitrogen fertilizer rates gradually increased plant growth, yield components and chemical constituents of garlic plants during both seasons. Moreover, Ewais *et al.* (2016) found similar results.

Regarding the influence of combinations between various intercropping systems and nitrogen fertilizer rates, the data presented in Tables 5, 6 and 7 reveal that, the best combination treatment for increasing plant growth, cloves number and average of bulb weight as well as chemical constituents of garlic, was that of the treatment of 2: 2 or 2: 3 systems combined with nitrogen fertilizer at 70 kg N/ feddan compared to the other combination treatments, in most cases. On the other hand, fruit yield/feddan of garlic crop was significantly decreased with all combination treatments between intercropping systems and nitrogen fertilizer compared with control [garlic growing as sole crop and without nitrogen application] in both seasons. Moreover, under each treatment of intercropping systems growth, yield and chemical constituents of garlic plant were gradually increased with increasing N fertilization rates.

Furthermore, Abdelkader *et al.* (2018) reported that both intercropping system and fertilization treatments (each alone) increased caraway growth parameters, in turn, they together might maximize their influences leading to more fruit yields of caraway intercropped with onion. Gendy *et al.* (2018) on black cumin when intercropped with fenugreek and fertilized with NPK rates, found that there are an increase in plant growth and productivity.

Influence of intercropping system, nitrogen fertilizer rate and their combinations on competitive indices between coriander and garlic crops:

The data illustrated in Table 8 showed that used LER, ATER, and LUE % to represent coriander fruit yield and garlic bulb yield. Generally, it was clear that all utilized intercropping systems improved the competitive indices utilized under study in both seasons as compared to sole planting. Nevertheless, using system 2: 2 recorded the highest values of LER, ATER, and LUE % in both seasons. Coriander had a positive sign for aggressivity or dominance index (Ag), while the intercropped garlic had a negative value, showing that coriander was dominant and the garlic was dominated (Table 9). Coriander crop were shown to be more competitive (CR coriander > one) when intercropped with garlics than garlic plants alone were (CR garlic one) as presented in Table 10. In addition, Abdelkader and Mohsen (2016) on coriander and onion and Khashaba *et al.* (2023 b) on caraway and garlic found similar results.

Data listed in Table 8 showed that the control treatment (without nitrogen fertilization) showed the highest value of LER, ATER and LUE as compared to nitrogen fertilization treatments. The control plants exhibited a stronger competitive ratio and aggressiveness compared to

the other nitrogen rates in both seasons (Tales 9 and 10). All nitrogen fertilization levels surpassed the unit. The same results were stated by Li *et al.* (2009), Meawad *et al.* (2013) and Hamad (2017).

Table 8. Influence of intercropping system (A), nitrogen fertilizer rate (B) and their combinations on LER, ATER and LUE % between coriander and garlic crops during the two seasons

Treatments		Land equivalent ratio (LER)		Area × time equivalent ratio (ATER)		Land utilization efficiency (LUE%)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
Intercropping system (coriander: garlic as row ratio)							
Sole crop		1.000	1.000	0.966	0.966	98.28	98.28
1: 1		1.214	1.191	1.178	1.155	119.57	117.29
2: 2		1.343	1.351	1.304	1.309	132.37	133.00
2: 3		1.288	1.188	1.188	1.148	120.82	116.80
LSD 5%		0.002	0.015	0.002	0.015	0.19	1.44
Nitrogen fertilizer rate (N kg/feddan)							
Control		1.216	1.199	1.178	1.161	119.69	118.01
30		1.197	1.166	1.160	1.127	117.85	114.62
50		1.175	1.180	1.138	1.142	115.68	116.08
70		1.197	1.185	1.160	1.148	117.82	116.66
LSD 5%		0.011	0.008	0.011	0.008	1.11	0.80
Combination between intercropping system and nitrogen fertilizer rate							
Sole crop	Control	1.000	1.000	0.966	0.966	98.28	98.28
	30	1.000	1.000	0.966	0.966	98.28	98.28
	50	1.000	1.000	0.966	0.966	98.28	98.28
	70	1.000	1.000	0.966	0.966	98.28	98.28
1 : 1	Control	1.243	1.220	1.205	1.182	122.32	120.09
	30	1.226	1.187	1.190	1.150	120.79	116.81
	50	1.189	1.180	1.154	1.144	117.11	116.13
	70	1.199	1.179	1.163	1.144	118.05	116.12
2 : 2	Control	1.356	1.383	1.316	1.341	133.59	136.16
	30	1.338	1.322	1.299	1.279	131.84	130.01
	50	1.319	1.344	1.280	1.302	129.93	132.29
	70	1.361	1.356	1.322	1.315	134.11	133.55
2 : 3	Control	1.266	1.195	1.226	1.156	124.55	117.50
	30	1.225	1.154	1.186	1.114	120.49	113.36
	50	1.194	1.196	1.155	1.157	117.40	117.64
	70	1.229	1.207	1.188	1.168	120.84	118.71
LSD 5%		0.020	0.020	0.019	0.019	1.94	1.96

Table 9. Influence of intercropping system (A), nitrogen fertilizer rate (B) and their combinations on aggressivity values between coriander and garlic crops during the two seasons

Treatments		Aggressivity values for coriander (Acg)		Aggressivity values for garlic (Agc)	
		1st season	2nd season	1st season	2nd season
Intercropping system (coriander: garlic as row ratio)					
Sole crop		+ 0.000	+ 0.000	- 0.000	- 0.000
1: 1		+ 0.149	+ 0.125	- 0.149	- 0.125
2: 2		+ 0.197	+ 0.137	- 0.197	- 0.137
2: 3		+ 0.669	+ 0.569	- 0.669	- 0.569
LSD 5%		0.018	0.014	0.018	0.014
Nitrogen fertilizer rate (N kg/feddan)					
Control		+ 0.269	+ 0.228	- 0.269	- 0.228
30		+ 0.266	+ 0.161	- 0.266	- 0.161
50		+ 0.233	+ 0.212	- 0.233	- 0.212
70		+ 0.247	+ 0.229	- 0.247	- 0.229
LSD 5%		0.020	0.010	0.020	0.010
Combination between intercropping system and nitrogen fertilizer rate					
Sole crop	Control	+ 0.000	+ 0.000	- 0.000	- 0.000
	30	+ 0.000	+ 0.000	- 0.000	- 0.000
	50	+ 0.000	+ 0.000	- 0.000	- 0.000
	70	+ 0.000	+ 0.000	- 0.000	- 0.000
1 : 1	Control	+ 0.138	+ 0.134	- 0.138	- 0.134
	30	+ 0.165	+ 0.098	- 0.165	- 0.098
	50	+ 0.137	+ 0.126	- 0.137	- 0.126
	70	+ 0.158	+ 0.142	- 0.158	- 0.142
2 : 2	Control	+ 0.200	+ 0.158	- 0.200	- 0.158
	30	+ 0.196	+ 0.085	- 0.196	- 0.085
	50	+ 0.182	+ 0.138	- 0.182	- 0.138
	70	+ 0.211	+ 0.169	- 0.211	- 0.169
2 : 3	Control	+ 0.739	+ 0.622	- 0.739	- 0.622
	30	+ 0.703	+ 0.462	- 0.703	- 0.462
	50	+ 0.613	+ 0.586	- 0.613	- 0.586
	70	+ 0.621	+ 0.605	- 0.621	- 0.605
LSD 5%		0.039	0.022	0.039	0.022

Table 10. Influence of intercropping system (A), nitrogen fertilizer rate (B) and their combinations on competitive ratio between coriander and garlic crops during the two seasons

Treatments		Competitive ratio for coriander (CRcoriander)		Competitive ratio for garlic (CRgarlic)	
		1st season	2nd season	1st season	2nd season
Intercropping system (coriander: garlic as row ratio)					
Sole crop		1.00	1.00	1.00	1.00
1: 1		1.28	1.23	0.78	0.81
2: 2		1.34	1.23	0.74	0.81
2: 3		1.70	1.59	0.59	0.63
LSD 5%		0.03	0.01	0.01	0.01
Nitrogen fertilizer rate (N kg/feddan)					
Control		1.34	1.29	0.78	0.80
30		1.35	1.20	0.77	0.85
50		1.31	1.27	0.80	0.81
70		1.33	1.30	0.78	0.79
LSD 5%		0.03	0.01	0.02	0.01
Combination between intercropping system and nitrogen fertilizer rate					
Sole crop	Control	1.00	1.00	1.00	1.00
	30	1.00	1.00	1.00	1.00
	50	1.00	1.00	1.00	1.00
	70	1.00	1.00	1.00	1.00
1 : 1	Control	1.25	1.24	0.80	0.80
	30	1.31	1.18	0.76	0.85
	50	1.26	1.24	0.79	0.81
	70	1.30	1.27	0.77	0.79
2 : 2	Control	1.35	1.26	0.74	0.80
	30	1.34	1.14	0.74	0.90
	50	1.32	1.23	0.76	0.81
	70	1.37	1.28	0.73	0.78
2 : 3	Control	1.76	1.66	0.57	0.60
	30	1.75	1.48	0.57	0.68
	50	1.65	1.61	0.61	0.62
	70	1.63	1.63	0.61	0.61
LSD 5%		0.06	0.03	0.03	0.02

Utilizing combination between sole crop and different nitrogen fertilizer rates gave the lowest values in LER, ATER and LUE % compared to other combinations. Whereas, using combination between system 2: 2 and nitrogen fertilization at any rate gave the highest values of these competitive indices as compared to other combination in both seasons (Table 8). The optimal combination for this parameter and aggressivity was 2: 3 intercropping plus nitrogen fertilization (Table 9). Nevertheless, the combination of 2: 3 system with nitrogen fertilizer rates in both seasons produced the highest competitive ratio values for coriander, while the combination of 1: 1 or 2: 2 systems and different nitrogen rate produced the highest values for garlic (Table 10). These results are in line with those reported by Ojikpong *et al.* (2009) on sesame and soybean, El-Shafey and Zen El- Dein (2016) on maize and soybean, Abdelkader *et al.* (2018) on caraway and onion, Gendy *et al.* (2018) on black cumin and fenugreek and Hosseini and Hamzei (2025) on *Dracocephalum kotschyi* and green bean or common bean.

CONCLUSION

From the obtained results, it could be recommended that to achieve the highest fruit yield of coriander or garlic, farmers of North Sinai region must be intercropped coriander and garlic at 2: 3 system and fertilized plants with 70 kg N /feddan. From competitive indices analysis, the best combination treatment was 2: 2 intercropping system + 70 kg N /feddan. This to increase the land utilization efficiency with more yields of coriander and garlic components

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تأثير نظام التحميل بين الكزبرة والثوم ومعدل التسميد النيتروجيني على نمو وإنتاجية كلا المكونين ومؤشرات التنافسية

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قسم الإنتاج النباتي، كلية العلوم الزراعية البيئة، جامعة العريش، مصر.

الملخص

أُجري هذا العمل في المزرعة التجريبية كلية العلوم الزراعية البيئية، جامعة العريش، محافظة شمال سيناء، مصر، خلال موسمي الشتاء المتتاليين لعامي ٢٠٢٢/٢٠٢٣ و٢٠٢٣/٢٠٢٤ لدراسة تأثير معدلات التسميد النيتروجيني المختلفة (صفر، ٣٠، ٥٠ و٧٠ كجم نيتروجين/فدان)، ونظم التحميل المختلفة (المحصول المنفرد لكل مكون ككنترول، ١:١، ٢:٢ و٣:٢ كنسبة صف من الكزبرة: الثوم، على الترتيب) ومعاملات التداخل بينهما على صفات النمو ومكونات المحصول ومؤشرات التنافس بينهما. أوضحت النتائج المتحصل عليها أن أعلى القيم لنمو الكزبرة والثوم ومكونات المحصول والنسب المئوية من الكربوهيدرات الكلية والنيتروجين عند تحميل الكزبرة مع الثوم بنظام ٢ :٣ مقارنة بالمحصول المنفرد لكل منهما وأنظمة التحميل الأخرى قيد الدراسة. مقارنة بمعدلات النيتروجين الأخرى قيد الدراسة، أدى تطبيق النيتروجين كإضافة أرضية ثلاث مرات في الموسم بمعدل ٧٠ كجم نيتروجين/فدان إلى الحصول على أعلى إنتاجية لأبصال الثوم لكل فدان وبذور الكزبرة لكل نبات وفدان. وخلصت الدراسة إلى أن معاملة التداخل المثلى، بناءً على تحليل المؤشرات التنافسية، وهي معاملة نظام تحميل ٢ : ٢ مع التسميد النيتروجيني بمعدل ٧٠ كجم نيتروجين/فدان حيث كانت نسبة المكافئ الأرضي (١,٣٦١ و١,٣٥٦)، ونسبة المكافئ الزمني × وحدة المساحة (١,٣٢٢ و١,٣١٥)، والنسبة المئوية لكفاءة استخدام الأرض (١٣٤,١١ و١٣٣,٥٥٪). كما أظهر تقدير العدوانية (أ) أن الكزبرة هي المحصول السائد والثوم هو المحصول المسود عليه.