Available online at www.sinjas.journals.ekb.eg
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SINAI Journal of Applied Sciences
Print ISSN 2314-6079
Online ISSN 2682-3527
ARU-EGYPT SJAS

VEGETATIVE GROWTH AND YIELD OF FABA BEAN AND ONION PLANTS AS AFFECTED BY THEIR INTERCROPPING AND PLANTING DISTANCES UNDER EL-ARISH REGION CONDITIONS

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ARTICLE INFO

Article history:
Received: 26/11/2021
Revised: 30/12/2021
Accepted: 14/01/2022
Available online: 01/02/2022

Keywords:
Faba bean; onion; intercropping patterns; planting distances.

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ABSTRACT

A field experiment was conducted during two successive seasons 2019-2020 and 2020-2021 in The Experimental Farm of the Faculty of Environmental Agricultural Sciences, Arish University, North Sinai, Egypt. The aim was studying the effect of the combination between faba bean and onion plants intercropping and planting distances. Faba bean cv. was “LUS DE OTO” (Spanish), while onion cv. was "Shamah", planting distances for the faba bean seeds were 25, 30, and 40. The planting distances for onion seedlings were 10, 12, and 8 cm. Every five rows of onion were with one row of faba bean with a distance of 20 cm. Accordingly, faba bean seeds were sown and onion seedlings were transplanted by hand on the second week of October and middle of December, respectively in both seasons. The drip irrigation system was used in this experiment. The experiment was designed in a randomized complete block design, in three replications. The results showed that a wide distance of 40 cm for bean plants and a narrow distance of 8 cm for onion seedlings recorded the highest values for vegetative growth characteristics *i.e.*, root length, plant height, number of leaves, number of branches/plant and both fresh and dry weight of bean plants and, plant height, leaf length as well as number of leaves/plant of onion plants at 90 and 120 days after planting. While the green pod yield /m^2 and yield bulbs g/m^2 were increased significantly by application of the intercropping system and narrow planting spaces for each faba bean (25 cm) and onion (8cm) plants. It could recommend intercropping with an increasing plant density of faba bean and onion plants under drip irrigation system, EL-Arish conditions, and similar regions to increase the yield.

INTRODUCTION

Faba bean is an important economic crop, due to its symbiotically atmospheric nitrogen fixation capacity which adds valuable nitrogen to the soil (**Wenxue *et al.*, 2005**). Also due to its high amount of protein among the legumes (**Matthews, and Marcellos 2003**). It is a valuable crop for intercropping with other crops, such as onion plants. Onion (*Allium cepa* L.) belongs to the genus Allium of the family Alliaceae (**Hanelt, 1990**). It is economically important for local consumption and export. On the other hand, it is suitable for intercropping with faba bean in terms of the timing of agriculture, as well as agriculture services, irrigation, nutrition and growth. Alliums are typically plants of open, sunny, dry sites in fairly arid climates; however, many species are also found in the steppes, dry mountain slopes, rocky or stony open

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https://doi.org/10.21608/SINJAS.2022.107622.1068

sites, or summer dry, open, scrubby vegetation (**Hanelt, 1990 and Kahsay *et al.* (2013)**. The control of plant spacing is one of the cultural practices to control bulb size, shape and onion yield (**Geremew *et al*., 2010**).

North Sinai region soilis sandy or sandy calcareous, where its organic content and nutrients are low as well as the presence of calcium carbonate, which affects the absorption of certain nutrients, so it is classified as low-productivity soil for agricultural crops. Therefore, limited areas face the high requirements, especially for food production. In the same time, there is need for not only increase production, but also the ability to grow multiple crops in small areas. So, good practices were used to achieve this economically and environmental goal.

Intercropping as a method of sustainable agriculture is the simultaneous growing of two or more crops during the same season on the same area, which utilize common limiting resources better than the species grown separately as an efficient resource use method (**Ghosh *et al*., 2006; Sobkowicz, 2006**). Also, one of the good factors that can be done to increase production from the unit area is to cultivate at different distances (intra and inter-row) by exchanging Faba bean, which are also proposed to be grown at different agricultural distances, and to perform an appropriate analysis of their interaction with a view to making optimal use of the unit area and increasing production. Thus, cropping systems have several benefits to the farmers such as, flexibility, profit maximization, risk minimization against total crop failure or disease, weed control, increase land use efficiency, soil conservation, improvement of soil fertility using legumes, enhancing the capture and use of light and water (**Dhima *et al*., 2006**). Therefore, the objective of this work was to investigate the intercropping of Faba bean with onion, regarding plant and growing traits to study if the combination can use resources more efficiently compared to sole cropping and so produce higher profitability. Faba bean and onion are in the list of compatible crops that can be produced in Arish location. So, the intercropping patterns are assessed to determine the best densities and efficiency of resource utilization by determining advantageous indices for achieving the highest production of faba bean and onion as well as higher land equivalent ratio by using intercropping and condensation methods while reducing or maximizing production costs under North Sinai conditions.

MATERIALS AND METHODS

A field experiment was conducted during two successive seasons of 2019-2020 and 2020-2021 in The Experimental Farm of Environmental Agricultural Sciences Faculty, Arish University, North Sinai, Egypt. The aim was studying the effect of combination between faba bean and onion plants intercropping and planting distances. Faba bean *cv*. was "LUS DE OTO" (Spanish), while onion *cv*. was "Shamah ". Planting distances for the faba bean seeds were 25, 30, and 40cm. The planting distance for onion seedlings were 10, 12, and 8 cm. Every five rows of onion were intercropped with one row of faba bean with a distance of 20 cm apart.

Faba bean was established before transplanting the onion at a_i (a_1, a_2 and a_3) intra-row spacing, while the onion seedlings intercrop comprised the b_i ($b_1 \times b_1$, $b_2 \times b_2$ and $b_3 \times b_3$) planting spaces (b=intra and inter line spacing), the intra-row spacings were 25, 30 and 40 cm for faba bean with 100 cm inter-row spacing. Two months old onion seedlings (Red onion *cv*.) were separately intercropped with faba bean, where one row of faba bean alternated with five lines of onion at a space of 10x10 cm, 12×12 cm and 8×8 cm. in five treatments (three intercropping patterns including different faba bean and onion proportional areas on 1 m wide area for each pattern) as follows:

1) Sole faba bean planting as a control
2) Sole onion planting as a control
3) Intercropping system a_1b_1, *i.e.*, planting one side of faba bean (25 cm intra row × 50 cm inter-row) alternated with 5 onion lines (10×10 cm) in the other side (50% of the same 1 m area)
4) Intercropping system a_2b_2; *i.e.*, planting one side of faba bean (30×45 cm) alternated with 5 onion lines (12×12 cm) in the other side (40% of the same 1 m area)
5) Intercropping system a_3b_3; *i.e.*, planting one side of faba bean (40×50 cm) alternated with 5 onion lines (8×8 cm) in the other side (60% of the same 1 m area) Therefore, the intercropping area ratios occupied by faba bean and onion were 50%:50% (1:1), 40%:60% (1:1.5) and 60%:40% (1.5:1), respectively for the three respective patterns. Each intercropping plot consisted of four rows (including the onion lines of 10 meters long with inter-row spacing 1 m. Gangways of 0.5 m between plots and 1 m between replications were employed. The intra-row spacing of faba bean and onion monocultures was 25 and 10 cm, respectively. Plot area was 24 m^2 (4-rows × 0.6 m wide × 10 m long for sole faba bean and 12-lines × 0.2 m × 10 m for sole onion). The experiment was designed in a randomized complete block design, and randomly distributed five treatments in three replications. In both seasons, faba bean seeds were sown and onion seedlings were transplanted by hand on the second week of October and middle of December, respectively. All agricultural practices necessary to produce faba bean have been implemented as followed by the technical recommendations of the Ministry of Agriculture and Soil Reclamation, the soil is classified as sandy loam.

Data Recorded

Faba bean plants

Vegetative growth parameters

Samples of five plants from each treatment were randomly taken after 60, 90, and 120 days after planting and the following data were recorded: root length, plant height, number of branches, number of leaves/plant, both fresh and dry weight of plant.

Growth attributes

Relative growth rate (RGR) it is defined as the increase of plant dry weight per unit of time (g/g/day) it was computed according to **Watson (1958)**. RGR= $\log_e w_2 - \log_e w_1 / t_2 - t_1$ Where: $\log_e w_1$ and $\log_e w_2$ refer to log of dry weight for two samples at time t_1 and t_2 in day, respectively.

Green yield

Faba bean pods at the marketable stage were harvested and the following data were recorded; pod length (cm), number of seeds/pod, number of pods/plant, pod weight (g/plant) and green pod yield (g/m^2).

Onion plants

Vegetative growth parameters

Fifteen plants from each treatment were randomly taken after 60, 90, and 120 days after transplanting and the following data were recorded: plant height (cm), number of leaves/plant and leaf length.

Growth attributes

Relative growth rate (RGR) it was computed according to **Watson (1958)**.

Bulb traits

Bulb length (cm), bulb diameter (cm), and bulb shape.

Onion bulb yield traits

Bulb fresh and dry weight (g), and yield (g/m^2).

Statistical Analysis

Analysis of variance was done on the two-year data for a Randomized Complete Block Design according to **Gomez and Gomez (1984)**. Means were compared by Duncan's multiple range tests (**Duncan, 1955**). For the analysis, the M stat C software was utilized.

RESULTS AND DISCUSSION

Faba Bean Plants

Vegetative growth

Results in Table 1 show the effect of plant density on vegetative growth traits such as root length, plant height, number of leaves and number of branches/plant, in 2019-20 and 2020-21 winter seasons. Sowing faba bean seeds at 40 cm recorded the highest root length (both seasons) as well as both tallest plants and number of leaves/plant (second season) at 60 days after sowing, whereas no significant differences were observed between all intra-spacing for plant height and number of leaves in 1st season and number of branches in both seasons at 60 days after planting (DAP) as well as between the distance of 30 cm and 40 cm for plant height at both 60 and 90 DAP in both seasons, and 120 DAP in first season. These results may be attributed to that wider plantation had less competition between plants for water, mineral nutrients,… *etc*. factors that encourage plants to grow well. These results are in harmony with those reported by **Al-Suhaibani *et al.* (2013), Derya (2013) and Gezahegn *et al*. (2016)** for number of leaves and branches/plant. In contrast with those of **Shahein *et al.* (1995)** who found that plant height was not affected by increasing plant density of faba bean.

Presented results in Table 2 show the effect of different planting density (25 cm monoculture and each of 25, 30 and 40 cm of intercropping pattern) on plant fresh and dry weight during 60, 90 and 120 days after planting in2019-20 and 2020-21 winter seasons.

Results indicated that fresh and dry weights of faba bean plant in intercropping was significantly affected by faba bean densities at the three testing periods (Table2). Fresh and dry weights of faba bean plant in pure stand was greater than in a_1b_1 intercropping pattern and adverse line was observed in the two other intercropping patterns, *i.e.*, a_2b_2 and a_3b_3. The maximum fresh and dry weights of faba bean was produced under inter-cropping with higher onion density (62.5 plants/m^2) at the three periods (60, 90 and 120 DAP). On the other hand, the lowest values for each of fresh and dry weight/plant was obtained with sowing faba bean seeds at a_1b_1 intercropping pattern (25 cm) in both growing seasons.

From the above-mentioned results, it could be concluded that plants grown under wider spaces received more nutrients, light and moisture around each plant compared to plants in closer spaces which is probably the cause of better performance of total dry weight of individual plants in wider spaces. The simulative effect of low plant density on dry weight of plant may be due to that wide spacing make a marked increase in vegetative growth, which in turn reflected on the content of plant dry weight. These results are in harmony with those reported by**Abubaker (2008)**.

Growth attributes

Results in Table 3 shows that insignificant differences among faba bean planting spacing in relative growth rate at two growth periods (60-90, and 90-120) days after sowing in both seasons.

Table 1. Effect of spacing on vegetative growth characters of faba bean plants during 2019-20 and 2020-21 seasons

Character / Planting Spacing (cm)	Root length (cm)	Plant height (cm)	No. Leaves	No. branches
60 days after sowing				
First season				
25 cm (Sole faba bean)	11.89ab	32.93a	58.67a	2.22a
25 cm (intercropped)	9.24b	32.39a	52.12a	1.22a
30 cm (intercropped)	12.33ab	36.26a	59.27a	2.11a
40 cm (intercropped)	15.11a	35.03a	67.89a	2.11a
Second season				
25 cm (Sole faba bean)	13.44b	35.67b	82.84c	2.11a
25 cm (intercropped)	11.46c	35.03b	77.22d	2.09a
30 cm (intercropped)	14.79b	36.66ab	86.98b	2.18a
40 cm (intercropped)	18.34a	38.14a	97.16a	2.24a
90 days after sowing				
First season				
25 cm (Sole faba bean)	24.49c	59.09b	116.66bc	3.55a
25 cm (intercropped)	23.83d	53.16c	96.66c	3.44a
30 cm (intercropped)	25.87b	67.63a	126.66b	2.66b
40 cm (intercropped)	28.72a	68.22a	172.22a	3.77a
Second season				
25 cm (Sole faba bean)	27.46a	64.44b	143.07c	4.08b
25 cm (intercropped)	23.97b	55.80c	139.53c	3.46c
30 cm (intercropped)	27.55a	69.27a	165.61b	4.68a
40 cm (intercropped)	29.54a	70.13a	219.79a	4.89a
120 days after sowing				
First season				
25 cm (Sole faba bean)	29.61c	62.47b	251.11b	4.56a
25 cm (intercropped)	27.54d	87.02a	156.44c	3.33b
30 cm (intercropped)	31.43b	84.27a	230.77b	4.59a
40 cm (intercropped)	33.14a	93.51a	369.23a	5.44a
Second season				
25 cm (Sole faba bean)	32.26b	66.19c	285.38c	5.53b
25 cm (intercropped)	29.79c	87.66b	201.66d	4.073c
30 cm (intercropped)	33.77ab	87.51b	346.52b	6.11ab
40 cm (intercropped)	34.44a	97.15a	407.81a	6.51a

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to Duncan's multiple range test.

Table 2. Effect of spacing on plant fresh and dry weights of faba bean plants during 2019/2020 and 2020/2021 seasons

Characters / Planting space (cm)	60 DAP		90 DAP		120 DAP	
	Plant fresh weight (g)	Plant dry weight (g)	Plant fresh weight (g)	Plant dry weight (g)	Plant fresh weight (g)	Plant dry weight (g)
			First season			
25 cm (monocultured)	71.03bc	8.62b	119.73c	12.51c	220.58c	33.22b
25 cm (intercropped)	60.87c	6.86b	88.44d	10.28c	120.82d	20.38c
30 cm (intercropped)	78.94b	9.60b	144.44b	16.38b	255.62b	38.69b
40 cm (intercropped)	93.35a	14.49a	162.43a	22.01a	330.46a	60.12a
			Second season			
25 cm (monocultured)	75.96c	12.34c	124.95c	15.02c	226.71b	38.60bc
25 cm (intercropped)	68.75d	8.79d	96.17d	12.93d	133.78c	27.59c
30 cm (intercropped)	84.53b	15.49b	151.57b	19.37b	264.15ab	47.36b
40 cm (intercropped)	97.87a	19.46a	173.22a	29.22a	343.49a	66.15a

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to Duncan's multiple range test.

[Z:] DAP =days after planting

Table 3. Effect of planting spaces on relative growth rate of faba bean during 2019/2020 and 2020/2021 seasons

Character	Relative growth rate (g/g/day)			
	Days after sowing			
Planting space (cm)	60-90 1st season	60-90 2nd season	90-120 1st season	90-120 2nd season
25 cm (monocultured)	0.011a	0.008a	0.028a	0.027a
25 cm (intercropped)	0.012a	0.011a	0.020a	0.022a
30 cm (intercropped)	0.016a	0.006a	0.025a	0.026a
40 cm (intercropped)	0.012a	0.012a	0.029a	0.023a

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to Duncan's multiple range test.

Green yield attributed traits

Results in Table 4 show the effect of plant spacing on pod length, number of seeds/pod, number of pods /plant, pod weight/plant and green pod yield/m^2. The main effect of plant spacing was significant on these pod traits in both seasons except, number of seeds per pod at the 2nd season.

Pod length was significantly increased as the intercropped intra-row spacing increased from 25 cm to 40 cm resulted in significantly longest pod in the wider plant spacing (40 cm). While the shortest pod achieved with 25 cm intercropped plant spacing. These results are true in both seasons with no significant differences between 30 and 40 cm planting spaces in 2nd season.

Similarly, each of number of seeds, number of pods/plant and green pod weight/plant were significantly increased as the intra-row spacing of intercropping patterns increased from 25 cm to 40 cm resulted in significantly seeds and pods numerous under the wider plant spacing (40 cm) with no significant differences between 25 and 30 cm spaces in 1st season for number of pods/plant and between all intercropping treatments for both number of seeds/pod and number of pods/plant in 2nd season.

The lowest values of the three traits achieved with narrow spacing (25 cm) of intercropping treatment in both seasons. The increase in number of pods per plant in lower population density may be due to vigorous plants as in lower population density; plant grew vigorously and produced more branches which resulted in high number of pods per plant **(Munakamwe *et al.*, 2012; El-Sherbini, 2015).** On the other hand, in higher plant population, spread of plants was decreased and resulted in less number of pods per plant **(Sajid *et al.*, 2012)**.

As for seeds/pod, this result is of the same order as **Gritton and Eastin (1968)** and greater than **Younkin *et al*. (1950)** over equivalent density ranges, it is considerably less than the equivalent range of **Meadley and Milbourn (1970)**. They have obtained increases up to the maximum plant population but, none of these workers used as high maximum plant density as in this trial.

Pod yield/m^2 was significantly increased as the intercropped intra-row spacing increased up to 30 cm and then significantly decreased at 40 cm wider spacing resulted in highest yield in the medium plant spacing (30 cm) which is fewer than monoculture treatment. While the lowest yield achieved with 25 cm of intercropping plant spacing. These results are true in both seasons. Generally, increases in plant density of intercropping systems result in additional input cost, but does not significantly return an increase in yield **(Yucel, 2013)** over monoculture. **Zaimoglu *et al.* (2004)** stated that yield increased with the increasing plant density up to a maximum level and declined when plant density was increased further. Results showed that use of high-quality certified seeds are required to obtain adequate plant number per unit area for maximum yield. Within certain limits, increase of plant population density decreases the growth and yield per plant but the reverse occurs for yield per unit area **(Caliskan *et al.*, 2007).** However, there are also trials that had exhibited no yield response to narrow rows **(Pedersen and Joseph, 2003)**. At wider spacing, greater nutrients uptake and improved light environment and water at lower plant population, hence the competition was low which would increase branching, flowers, and pods yield/ plant. Pods number and weight as the major yield parameters reflect the plant performance during previous growth stages, which depend mainly on the vigorous of vegetative growth and flowering status. The obtained results are in agreement with those reported by **El-Seifi *et al.* (2014), Masa *et al.* (2017) and Mostafa *et al.* (2019)**.

Table 4. Effect of planting spaces on green pod traits of faba bean during 2019/2020 and 2020/2021 seasons

Planting space (cm)	Pod length (cm)	No. of pods /plant	No. of seeds/pod	Green pod weight/plant(g)	Green pod yield (g/m^2)
			First season		
25 cm (monocultured)	14.87b	24.31c	5.71c	591.56c	3939.79a
25 cm (intercropped)	12.27c	26.13b	5.31d	542.93d	2171.73d
30 cm (intercropped)	15.46b	27.36b	6.07b	845.4b	2815.21b
40 cm (intercropped)	17.51a	29.08a	6.41a	1020.22a	2550.55c
			Second season		
25 cm (monocultured)	16.47b	24.65b	6.68a	620.79c	4134.46a
25 cm (intercropped)	16.16b	26.50ab	6.45a	596.22d	2384.88d
30 cm (intercropped)	18.46a	28.84a	6.91a	971.91b	3236.47b
40 cm (intercropped)	18.95a	29.34a	7.16a	1136.66a	2841.66c

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to Duncan, s multiple range test.

Previously conducted studies show how unique situations and environmental conditions can influence the yield responses of narrow spacing in different ways. The varying impacts on narrow response make it difficult to predict yield gain in a given year. Other studies have shown similar trends with narrow spacing benefiting yield (**Parker *et al.*, 1981; Beatty *et al.*, 1982),** over wide ones regardless of planting dates. **Abd El-Haliem (2008)** demonstrated that the differences between plant densities were significant in total yield/m^2 and the highest values were obtained at high density.

Onion Plants

Vegetative growth

Rustles in Table 5 show the effect of plant density on vegetative growth traits; *viz*, plant height, number of leaves and leaf length in 2019-20 and 2020-21 seasons. Significant differences among intercropping and planting spaces were observed for all studied traits at all dates (60, 90 and 120 DAP) in both seasons, except number of leaves at 60 days.

Transplanting onion seedlings at a distance of 8×8 cm (a_3b_3) recorded the highest plant height and leaf length (both seasons) at 60, 90 and 120 DAP as well as number of leaves/plant (second season) at 120 days after sowing with no significant differences between this treatment (a_3b_3) and monoculture onion plants at all growth stages (60, 90 and 120 DAP) for all studied traits, except leaf length at 120 DAP in both seasons as well as between 8×8 cm, 12×12 cm and monoculture for number of leaves and leaf length at 90 DAP in both seasons, Plant height and leaf length at 90 DAP (first season) and both plant height and leaf length at 60 DAP and both plant height and number of leaves at 120 DAP in second season.

This result might be due to the fact that as the spacing among plants decreased the interplant competition for light increased. **Agajie (2018)** Came to similar results that sparsely populated plants intercepted sufficient sunlight that enhanced the lateral growth.

Table 5. Effect of spacing on plant height, number of leaves/plant and leaf length (cm) of onion plants during 2019-20 and 2020-21 seasons

Planting space (cm)	Plant height (cm)		No. of Leaves/plant		Leaf length (cm)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
			60 DAP			
10 cm (sole)	64.46ab	65.92ab	7.13a	7.53a	61.16ab	62.51ab
10 cm intercropped	57.43c	59.45b	6.33a	6.33a	53.53b	54.13b
12 cm intercropped	61.93b	62.57ab	6.66a	7.14a	58.91b	59.95ab
8 cm intercropped	66.03a	70.54a	7.11a	8.12a	64.73a	68.33a
			90 DAP			
10 cm (sole)	80.33a	83.73a	8.66a	9.31a	75.96a	77.41a
10 cm intercropped	74.83b	77.71c	6.01b	7.33b	67.53b	70.55b
12 cm intercropped	79.16ab	80.91b	8.33a	8.66a	74.16a	75.91ab
8 cm intercropped	81.26a	83.92a	8.66a	911a	77.26a	77.83a
			120 DAP			
10 cm (sole)	59.51ab	61.93a	8.11a	9.36a	54.62b	60.16b
10 cm intercropped	50.61b	56.43b	6.66c	7.33b	47.53c	51.32d
12 cm intercropped	52.93b	57.84ab	7.66b	8.66ab	53.61b	52.36c
8 cm intercropped	63.86a	65.43a	8.33a	9.23a	60.53a	63.03a

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to Duncan's multiple range test.

[Z:] DAP =days after planting

Growth attributes

Results in Table 6 shows that insignificant differences among onion plant spacing on the relative growth rate at two growth periods (60-90, and 90-120) days after sowing in both seasons.

Bulb traits

Results in Table 7 reveal that intercropping and planting spaces had no significant effects on some onion bulbs traits in both growing seasons at three times.

Generally, it is obvious that a_3b_3 intercropped onion/faba bean pattern with narrow spacing (8 cm) in onion plants of a_3b_3 intercropping pattern, recorded the highest result for bulb length (2nd season) and diameter (1st season) at 60 DAP as well as the two same traits at 90 DAP of both seasons. As for bulb shape, it is not significantly affected by application treatments, except in the first season at 60 days.

Bulb yield traits

Results in Table 8 show the effect of plant spacing on fresh bulb weight (g), dry Bulb weight (g) and bulb yield (g/m^2). The main effect of plant spacing was significant on these bulb yield traits in both seasons.

Table 6. Effect of spacing on relative growth rate during 2019/2020 and 2020/2021 seasons

Planting space(cm)	Relative growth rate (g/g/day)			
	Days after transplanting			
	60-90 1st season	60-90 2nd season	90-120 1st season	90-120 2nd season
25 cm (monocultured)	0.073a	0.043a	0.020a	0.019a
25 cm (intercropped)	0.062a	0.045a	0.021a	0.023a
30 cm (intercropped)	0.059a	0.051a	0.018a	0.021a
40 cm (intercropped)	0.060a	0.042a	0.018a	0.017a

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to Duncan, s multiple range test.

Table 7. Effect of spacing on bulb characters during 2019/2020 and 2020/2021 seasons

Planting space (cm)	Bulb length (cm)	Bulb diameter (cm)	Bulb shape	Bulb length (cm)	Bulb diameter (cm)	Bulb shape
	First season			Second season		
			60 DAP			
10 cm (sole)	1.62a	3.27a	2.02a	1.83ab	3.63a	1.98a
10 cm intercropped	1.53a	2.91ab	1.90b	1.67ab	3.11a	1.86a
12 cm intercropped	1.53a	3.07a	2.00a	1.75ab	3.31a	1.89a
8 cm intercropped	1.65a	3.30a	2.00a	2.03a	3.51a	1.73a
			90 DAP			
10 cm (sole)	4.84b	5.71b	1.18a	5.21a	5.91b	1.13a
10 cm intercropped	4.64b	5.17b	1.11a	4.84ab	5.52b	1.14a
12 cm intercropped	4.78b	5.46b	1.14a	5.17a	5.65b	1.09a
8 cm intercropped	5.06a	6.44a	1.27a	5.4a	6.65a	1.23a
			120 DAP			
10 cm (sole)	3.64a	4.39a	1.20a	3.83a	4.63ab	1.20a
10 cm intercropped	3.37a	4.31a	1.27a	3.54a	4.41ab	1.24a
12 cm intercropped	3.60a	4.38a	1.2a	3.95a	4.51ab	1.14a
8 cm intercropped	3.72a	4.84a	1.30a	3.84a	5.22a	1.35a

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to Duncan's multiple range test.

Table 8. Effect of spacing on bulb yield characters during 2019/2020 and 2020/2021 seasons

Planting space (cm)	Fresh bulb weight (g)	Dry bulb weight (g)	Yield (g/m^2)	Fresh bulb weight (g)	Dry bulb weight (g)	Yield (g/m^2)
	1st season			2nd season		
10 cm (sole)	46.12c	11.99b	2306c	51.56c	13.63ab	2578d
10 cm intercropped	59.25b	11.52b	5925b	60.69b	12.46b	6069b
12 cm intercropped	71.62a	11.65b	4973.29b	72.88a	13.11ab	5060.79c
8 cm intercropped	70.47a	13.63a	11010.94a	72.54a	14.09a	11334.38a

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance, according to Duncan's multiple range test.

Fresh bulb weight was significantly increased as the intercropped intra-row spacing increased from 10 cm to 12 cm and resulted in significantly heaviest bulb in the wider plant spacing (12 cm) with no significant differences between 12 cm and 8 cm intercropped intra-row spacing. While the lightest one was achieved with 10 cm intercropped plant spacing in which the fresh weight was heavier than monoculture bulb weight. These results are true in both seasons.

Similarly, dry weight of bulb was significantly increased in 8 cm intra-row spacing of intercropping pattern of a_3b_3 resulted in the significantly heaviest dry bulb weight under the narrow plant spacing (8 cm) with no significant differences between 10 cm of sole plants and both 10 and 12 cm spaces intra-row spacing of a_1b_1 and a_2b_2 intercropping patterns at both seasons. On the opposite, bulb yield(g/m^2) was significantly increased as the plant densities increased (intercropped intra-row spacing decreased from 12 cm to 8 cm resulted in significantly the heaviest bulb yield/m^2 in the closest plant spacing (8 cm) with no significant differences between 10 cm and 12 cm intercropped intra-row spacing in 1st season. While the lightest one was achieved with 10 cm monoculture plant spacing. The current result agrees with works of different authors. **Kahsay *et al.* (2013)** reported that highest total bulb yield was recorded at the closest intra-row spacing (5 cm) followed by 7.5 cm. Average bulb weight increased with increasing intra row spacing. Thus, total bulb yield can be increased as population density increases, that was in accordance with **Kantona *et al.*, (2003)** who noticed that onion yield increased from 17.4 to 39.5 t/ha as plant population per square meter increased from 50 to 150 cm. Previously conducted studies show how unique situations and environmental conditions can influence the yield responses of narrow spacing in different ways. The varying impacts on narrow response make it difficult to predict yield gain each year. Other studies have shown similar trends with narrow spacing benefiting yield **(Parker *et al.*, 1981; Beatty *et al.*, 1982)**, over wide ones regardless of planting dates. **Abd El-Haliem (2008)** demonstrated that the differences between plant densities were significant in total yield/m^2 and the highest values were obtained at high density.

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الملخص العربي

تأثر النمو الخضري والمحصول للفول البلدي والبصل بالتحميل ومسافات الزراعة تحت ظروف منطقة العريش

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أجريت تجربة حقلية خلال موسمين متتاليين (2020/2019 و2021/2020) بالمزرعة التجريبية لكلية العلوم الزراعية البيئية بجامعة العريش، شمال سيناء، مصر، وذلك لدراسة تأثير التحميل ومسافات الزراعة بين كل من نباتات الفول (صنف لويس دي أوتو "LUS DE OTO" الأسباني، والبصل صنف شاما Shamah". زرعت بذور الفول بجوار خطوط الري بالتنقيط بثلاث مسافات زراعية وهي 25 و30 و40 سم، أما مسافة زراعة شتلات البصل فكانت 10 و12 و8 سم بين الشتلات، على التوالي. وكانت الزراعة بمعدل كل خمسة صفوف من البصل مقابل صف واحد من الفول بينهما تباعد مسافة قدرها 20 سم. تم زراعة بذور الفول وشتلات البصل في الاسبوع الثاني من شهر اكتوبر ونصف شهر ديسمبر على التوالي في الموسمين. استخدام نظام الري بالتنقيط في هذه التجربة، وصممت التجربة في نظام القطاعات العشوائية الكاملة ووزعت المعاملات عشوائيا في ثلاث مكررات. حققت الزراعة على مسافات واسعة (40 سم) لنباتات الفول مع المسافات الضيقة (8 سم) لشتلات البصل أعلى القيم لصفات النمو الخضري متمثلة في طول الجذر، ارتفاع النبات، عدد الأوراق، وعدد الفروع/النبات، والوزن الطازج والجاف لنباتات الفول، وارتفاع النبات، وطول الورقة، بالإضافة إلى عدد الأوراق لنبات البصل عند 90 و120 يومًا من الشتل، بينما سجل محصول القرون الخضراء/م^2 ومحصول الابصال/م^2 زيادة معنويه باستخدام انظمة التحميل ومسافات الزراعة الضيقة لكلا من نباتات الفول (25سم) ونباتات البصل (8سم). لذلك يمكن التوصية باستخدام نظام التحميل مع زيادة الكثافة النباتية لنباتي الفول والبصل تحت ظروف الري بالتنقيط بمنطقة العريش والمناطق المشابهة لها لزيادة المحصول.

الكلمات الإسترشادية: الفول، البصل، نظام التحميل، مسافات الزراعة.

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