



Performance of five Faba bean varieties under different irrigation intervals and sowing dates in newly reclaimed soil

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Abstract

In order to study the effect of irrigation and sowing date on plant characteristics, chemical and yield traits of five faba bean cultivars, an experiment was conducted in two growing seasons in the farm of the Faculty of Agriculture, Demo, Fayoum University, Egypt. Using split-split plot in RCBD with three replications. Irrigation intervals (I) was considered as the main plot in the three intervals (irrigation every 20, 30 and 40 days). Three sowing dates (22ndOct., 7th and 22ndNov.) were arranged in the sub plot. The sub-sub plots were varieties (Nubaria1, Nubaria2, Giza3 improved, Sakha1 and Sakha2). Results indicated that the effect of irrigation every 20 days (I₁) surpassed the others two where it produced higher values of plant height (87.34cm), seed yield (1.81ton/feddan) and carbohydrate % (46.73%). The early sowing date (22nd October) produced the highest values of all yield attributes and carbohydrate percentage with the exception of harvest index and protein percentage in combined analysis. Giza3 improved achieved the superiority only on plant height trait, while Nubaria2 achieved the superiority on number of pods/plant and height to first pod. While, Nubaria1 variety presented the first class in number of branches, pods and seeds weight/plant, 100-seed yield, seed and straw yield and carbohydrate %. The highest values of pods and seeds weight/plant were 57.04 and 45.32gm, as well as 100-seed weight (gm) and seed yield (ton/fed.) were 118.37 (gm) and 2.04 (ton/fed.) respectively, were obtained by irrigation every 30 days with early sowing with Nubaria1 variety.

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Introduction

Faba bean (*Vicia faba* L.) considered as one of the fundamental wellsprings of modest protein and vitality in Africa, parts of Asia and Latin America, where a great many people can't manage the cost of meat as a source of protein (Duc, 1997 and Haciseferogullari *et al.*, 2003). Moreover, it is play a noteworthy part in animal forage.

The crop plays a beneficial role in the crop rotation, due to its fixation ability of atmospheric nitrogen. Besides, enhances the soil with nitrogen it increases its contents of organic matter and water which essential for productivity of the cropping system, particularly in dry rain fed areas. Faba bean is an indispensable crop in organic agricultural system as valuable nitrogen source in crop rotation. The crop also used as green manure. In addition, faba bean is an important food pulse crop, whereit ranked as the 6th most vital legume crop on the planet, after soybean, peanut, beans, peas and chickpea (Hendawey and Younes, 2013) because of the abundance of low drift protein and other fundamental sustenance, such as, phosphorus, potassium, calcium, sulfur and iron, faba bean plays a noteworthy say in human nourishment.

In Egypt, the cultivated area with faba bean was 131.428, 97.906, 104.917, 89.707 and 81.934 thousand feddan with an average seed yield of 1.324, 1.423, 1.486, 1.469 and 1.449 t/fed. in 2010/2011, 2011/2012, 2012/2013, 2013/2014 and 2014/2015 seasons, respectively which is mainly spread in North Egypt governorates (54.48%) especially at Bahera, Kafr-El sheikh, and Dakahlia. Area under cultivation in middle, Upper Egypt and outside the valley in newly reclaimed soil represent 2.69%, 7.99% and 34.84% respectively, from the total acreage in Egypt at 2014/2015 season.

The total local production of this crop is still insufficient to cover the local consumption, due to yearly decreased area and moderate productivity from the previously mentioned certainties, there is awesome need to defeat this gap between production

and request by development through recovered reclaimed lands, which represented the most hope of cultivated lands in increasing our agriculture production and subsequently in overcoming the deficiency in food requirements. An alternative way is increasing the vertical production through introduction of new varieties with high yield potential.

The irrigation intervals, sowing dates and valid varieties considered as basic components of technical packages for crop management in the arid region, which prompt to high efficiency. Faba bean answered to be more delicate to water shortfall than some other grain legumes. Sensitivity is due to its maximum depth of rooting being relatively shallow approximately 0.9 m and its disability to modify physically to water stretch (Hebblethwaite, 1982).

Notwithstanding, water is the most restricting normal source for agricultural production in dry and semi-dry areas, the aggregate yearly water of Egypt are around 67.27- billion m³ (Abo Zied, 2000). The agriculture expends just about 80 - 90 % of the aggregate water allotted to Egypt. The regularly expanding of the Egyptian population and the restricted water quantity prompted to an enduring abatement in per capita share of water and thus diminishing plant water utilization, this need utilizing more effective water system strategies (Tayel *et al.* 2007), Plant breeding technology, longer irrigation intervals, higher moisture depletion, skipping irrigation during the early vegetative growth or during maturation stage, and timing of the length of irrigation interval with the stage of plant growth.

This will save irrigation. Sowing date is a standout amongst the most imperative agronomic variables identified with crop growth and yield. It affects greatly the time and duration of vegetative and reproductive growth as well as the degree of infection with plant diseases and insect pests.

Selecting the promising varieties and appropriate irrigation intervals as well as effective sowing dates are very essential parameters for faba bean yield and quality.

It is obvious that yield is the product of the genetic composition and environmental condition prevailing during plant growth. The genetic pattern is relatively fixed for a given variety but the environment affects the development through its interaction with genetic composition. The goal of the present work was to perceive the reasonable blend for irrigation intervals, sowing date and varieties for maximum faba bean seed yield and its component thunder the states of newly reclaimed soil.

Materials and methods

Experimental Design and Field Management

Two field experiments were carried out in the farm of the Faculty of Agriculture, Demo (29°17' N; 30°53' E), Fayoum University, Egypt, during the two successive winter seasons of 2013/14 and 2014/15. The objective of this investigation was to study the effect of irrigation intervals and sowing dates on plant characteristics, chemical and yield traits of five faba bean varieties. Each experimental basic unit included 5 ridges, 60 cm apart and 3.5 m long, comprising an area of 10.5 m² (1/400 fad.).

The soil of experimental was heath in the first season, while the preceding summer crop was Sesame (*Sesamum indicum* L.) in the second season.

The recommended agricultural practices for growing faba bean were followed except the factors under study which arranged in split-split plot in randomized complete block design with three replications. Since the trend was similar in both seasons, the combined analysis of the two growing seasons was done. The main plots were assigned to Irrigation intervals (I), irrigation water was utilized throughout three irrigation intervals viz: I₁=irrigation every 20 days, I₂=irrigation every 30 days and I₃=irrigation every 40 days. Sowing dates (S), three different sowing dates used in this study viz: S₁ = 22nd October, S₂ =7thNovember and S₃ =22nd November in two seasons were arranged in the sub treatments. The sub-sub plots were occupied with five faba bean varieties i.e., Nubaria 1, Nubaria 2, Giza 3 improved, Sakha 1 and Sakha 2. Half monthly weather data at Fayoum, Egypt as average for two growing seasons 2013/2014 and 2014/2015 of study are presented in Table 1.

Table 1. The maximum, minimum and mean daily temperature in centigrade and relative humidity (R.H.), in percentage at half monthly intervals from October to May in 2013/2014 and 2014/2015 seasons at Fayoum province as taken from the meteorological department, Fayoum.

Season	Period	2013/2014					2014/2015						
		Temperature (C)			R.H%		Temperature(C)			R.H%			
		Max.	Min.	Daily mean	Max.	Min.	Daily mean	Max.	Min.	Daily mean	Max.	Min.	Daily mean
October	1-15	30.85	20.43	25.64	72.47	24.67	48.57	35.97	22.97	29.47	76.00	20.07	48.04
	16-31	30.73	18.64	24.69	63.88	12.94	38.41	33.69	20.19	26.94	75.94	19.00	47.47
November	1-15	30.01	18.51	24.26	64.73	14.73	39.73	31.59	17.89	24.74	75.33	23.07	49.20
	16-30	28.26	16.44	22.35	63.27	20.73	42.00	27.15	16.53	21.84	76.93	30.53	53.73
December	1-15	23.76	13.23	18.50	66.67	24.2	45.44	27.64	14.16	20.90	76.73	25.67	51.20
	16-31	23.83	10.11	16.97	68.25	23.51	45.88	24.65	10.44	17.55	77.38	24.69	51.04
January	1-15	22.79	10.00	16.40	67.60	24.80	46.20	19.59	9.97	14.78	71.73	28.80	50.27
	16-31	24.45	9.40	16.93	66.94	17.25	42.10	25.13	10.45	17.79	76.63	20.50	48.57
February	1-15	24.97	10.60	17.79	67.67	18.33	43.00	24.11	10.57	17.34	72.53	22.00	47.27
	16-28	27.42	12.18	19.80	68.22	29.78	49.00	23.11	10.54	16.83	76.31	26.69	51.50
Mars	1-15	29.11	13.35	21.22	69.11	13.89	42.00	27.12	13.95	20.54	79.40	23.60	51.50
	16-30	31.93	15.58	23.75	69.21	20.29	44.75	30.44	15.42	22.93	74.56	14.69	44.63
April	1-15	33.20	16.09	24.65	70.55	9.45	40.00	30.27	15.28	22.78	78.47	16.27	47.37
	16-31	36.43	18.97	27.70	70.20	10.80	40.50	35.33	16.11	25.72	72.47	13.53	43.00
May	1-15	35.95	20.15	28.05	70.27	14.13	42.20	34.35	20.09	27.22	72.53	6.80	39.67
	16-31	38.69	22.63	30.66	70.50	11.50	41.00	39.44	23.10	31.27	70.06	9.56	39.81

Table 2. Physical and chemical properties of experimental fields in two seasons.

Seasons	2013/2014	2014/2015
Physical Properties		
Sand (%)	74.9	75
Silt (%)	13.73	13.21
Clay (%)	11.37	11.79
Soil Texture Class	Sandy Loam	Sandy Loam
Chemical Properties		

Seasons	2013/2014	2014/2015
Organic Matter (%)	0.64	0.62
ECe (ds. M ⁻¹ ; soil- paste extract)	3.60	3.59
pH (at a soil : water w/v ratio of 1:2:5	7.51	7.56
Total N%	0.05	0.05
Caco ₃ %	7.21	7.30

The studied traits

At maturity, random sample of ten guarded plants from each sub- sub plots in both seasons was taken to determine the following measurements: Plant height (cm), number of branches per plant on the main stem, number of pods / plant, the height to first pod, pods and Seeds weight per plant (in gm.). The whole faba bean plants of the two ridges of each sub- sub plots have been used for estimating of seed yield per feddan (ton), straw yield per feddan (ton), harvest index and 100 seed weight. As well as, chemical analysis samples of dry yields of seeds were ground into a fine powder for using in the following chemical analysis.

Crud protein percentage (Total nitrogen) was determined by using microkjeldahi as described A.O.A.C. (1995) and the obtained values were multiplying it by a factor 6.25 to obtain the protein percentage. Carbohydrates percentage was determined according to the method described by Dubois *et al.* (1956) with some modification by Orabi (1994).

Data Analysis

Analysis of variance was done for the data of each season separately and combined analysis was performed for the data over the two seasons according to Snedecor and Cochran (1980) treatment means were compared using least significant difference test at 0.05 level of significance.

Using the GENSTAT Version 12th 2009 " Statistical software package (VSN International, Hemel Hempstead, UK) (Payne, *et al.*, 2009).

Results and discussion

Effect of irrigation intervals

The presented data in Table (3) showed that irrigation intervals exhibited a significant difference for all studied traits except height to first pod, pods weight/ plant, straw yield and harvest index were no significant effect.

According to LSD test irrigation every 20 days (I₁) surpassed the others two where it produced higher values of plant height (87.34 cm), seed yield (1.81ton/ fed.) and carbohydrate % (46.73%). These effects are in agreement with those obtained by Moursi *et al.* (2014) and Mehasen *et al.* (2017) they reported that plant height, weight of 100 seeds and seed yield/fed., as well as, carbohydrate % were significantly increased by the shortest irrigation interval.

Increasing the mean values of the abovementioned studied parameters under the shortest irrigation interval (I₁) comparing with other irrigation treatments I₂ and I₃ might be due to that the irrigation treatment I₁ received the highest amount of water applied which increase the solubility and availability of nutrients and hence, increase the uptake of these nutrients by plants and yield components.

Effect of sowing dates

The faba bean yield attributes and chemical analysis significantly differed among three sowing dates as a shown in table 3. The early sowing date (22nd October) produced the highest values of all yield attributes and carbohydrate percentage with the exception of harvest index and protein percentage over two seasons. It was noticed that early sowing date (22nd October) caused significant increases in plant height 43.35%, number of pods 30.12%, height to first pod 84.29%, number of branches 85.43%, pods weight per plant 44.88%, seeds weight per plant 44.12%, 100 seed weight 2.69%, seed yield 15.06%, straw yield 42.86 % and carbohydrate 7.49% compared with delaying sowing date (22nd November). On the contrary, harvest index and protein percentage were significantly decreased by 12.02 and 2.98% in combined analysis, respectively, compared to early sowing date (22nd October).

The superiority of seed yield observed with the early sowing date might be attributed to the increase in plant height, number of pods, number of branches, pods weight per plant, seeds weight per plant and 100 seed weight. These findings confirm the results obtained by Alazaki and Al Shebani (2012), Abdou *et al.* (2013), Badr *et al.* (2013) and Ibrahim (2016) they obtained that early sowing date gave the highest mean values for plant height, number of branches, number of pods, pods and seeds weight per plant, 100 seed weight and seed yield. As well as, Shaban *et al.* (2013) confirmed that 25th November gave the highest value of protein percentage. While, I didn't agree with Hegab *et al.* (2014) who obtained that (1st of November) surpassed the others sowing dates in carbohydrate and protein percent.

Effect of varieties

Significant varieties differences were showed in all yield attributes and chemical analysis as presented in table 3 as average of the combined analysis. Giza 3 improved achieved the superiority only on plant height trait, while Nubaria 2 achieved the superiority on number of pods per plant and height to 1stpod. While, Nubaria 1 variety presented the first class in number of branches, pods and seeds weight per plant, 100 seed weight, seed and straw yields and carbohydrate %. These results are in agreement with those obtained with Bakry *et al.* (2011), Abo- Khalil *et al.* (2015) who found that Nubaria 1 variety achieved the superiority on seed yield/ feddan, number of branches per plant, seeds weight and 100- seed weight while the superiority went in harvest index and protein % to Sakha 1 variety.

These results are similar to Abido and Seadh (2014) and Khalil *et al.* (2015) and who found that Sakha 1 variety achieved the first order in harvest index and protein percentage.

These results may be attributed to the differences between studied cultivars in growth habit and response of each one to environmental conditions, during the growing season which are controlled by nodulation and N-fixation consequently growth characteristics

Interaction effects

Effect of the interaction between irrigation intervals and sowing dates.

Significant effect of interaction between irrigation intervals and sowing dates was obtained for all yield and yield components and chemical traits on faba bean (Table 4).

Data in table 4 showed that early sowing date (22nd October) combined with irrigation every 40 days (I₃) gave the highest values in plant height (106.82cm), number of branches and pods per plant (3.07 and 12.11), pods and seeds weight/ plant (43.82 and 33.24gm) and seed and straw yield (1.93 and 3.88 ton/fed.), while early. sowing date (22nd October).

combined with irrigation every 20 days (I₁) obtained the highest values in height to 1st pod (36.78cm), 100 seed weight (97.14gm) and carbohydrate % (48.57) whereas, late sowing date (22nd November) combined with irrigation every 20 days (I₁) presented the highest values in harvest index (41.66) and protein % (26.90).

Table 3. Effect of irrigation intervals, sowing dates and faba bean varieties on yield, yield attributes and chemical analysis (combined analysis over two seasons).

Treatments	Plant height (cm)	Number of pods/plant	Height to 1 st pod	Number of branches/plant	Pods weight/plant (g)	Seeds weight/plant (g)	100-seed weight (g)	Seed yield (ton/fed.)*	Straw Yield (ton/fed.)*	Harvest index	Carbohydrate %	Protein %
Irrigation intervals (I)												
I ₁	87.34	10.17	28.44	2.18	35.06	26.91	94.64	1.81	3.12	37.45	46.73	25.31
I ₂	85.55	9.67	28.63	2.13	34.03	25.70	95.54	1.79	3.18	36.47	44.95	25.18
I ₃	86.40	10.19	27.82	2.34	35.16	27.19	93.98	1.78	3.27	36.05	43.23	25.48
LSD (5%)	0.779	0.154	N.S.	0.066	N.S.	0.963	1.141	0.022	N.S	N.S	0.347	0.049
Sowing dates (s)												
S ₁	102.91	11.19	37.19	2.80	40.29	31.10	96.29	1.91	3.70	34.70	46.77	25.10
S ₂	84.58	10.25	27.53	2.34	36.15	27.12	94.10	1.80	3.28	35.82	44.63	25.00
S ₃	71.79	8.60	20.18	1.51	27.81	21.58	93.77	1.66	2.59	39.44	43.51	25.87
LSD (5%)	0.724	0.153	0.739	0.061	0.822	0.653	0.852	0.019	0.139	1.685	0.292	0.041

	Varieties (v)											
V ₁	83.99	8.46	29.32	3.21	36.23	28.38	110.92	1.89	3.58	34.86	46.39	24.49
V ₂	92.64	11.51	30.36	2.27	34.29	25.99	87.83	1.83	3.35	35.81	44.77	25.70
V ₃	95.89	11.49	29.51	1.65	33.98	25.98	85.91	1.87	3.25	37.10	42.93	25.39
V ₄	77.51	9.42	25.33	1.76	33.99	26.07	93.24	1.73	2.46	42.09	45.54	25.94
V ₅	82.12	9.18	26.96	2.19	35.27	26.58	95.71	1.63	3.31	33.42	45.21	25.11
LSD (5%)	1.109	0.167	0.809	0.073	0.870	0.643	1.414	0.022	0.134	1.216	0.271	0.055

*fed. = Feddan = 4200m²

Effect of the interaction between irrigation intervals and varieties

The interaction between irrigation and varieties was significant for all studied traits indicating that cultivars differently responded to irrigation intervals (Table 5). Nubaria 1 (V₁) under irrigation every 20 days gave the highest values in seed yield (1.92 ton/fed.) and carbohydrate % (48.25) also, under irrigation every 30 days gave the highest values in pods and seeds weight per plant (39.83 and 31.33gm) as well as, under irrigation every 40 days gave the topmost values in number of branches per plant, 100 seed weight and straw yield (3.85 ton /fed.). On the other hand, Giza 3 improved (V₃) under irrigation every 20 days gave the tallest plant (99.05cm), while, the topmost value of number of pods per plant (12.57) was obtained by Nubaria 2 (V₂) under irrigation every 20 days and gave the highest height to first pod (31.86cm) under irrigation every 40 days. The highest value for harvest index (47.13) was obtained by irrigation every 20 days combined with Sakha 1 variety. Meanwhile, for protein % Nubaria 2 combined with irrigation every 30 days achieved the highest rate (26.39). The previous findings are in harmony with those obtained by Abd Alla and Omran (2002), Tayel and Sabreen (2011).

Effect of the interaction between sowing dates x faba bean varieties

Data in table 6 showed a significant for all studied characters indicating that cultivars differently responded to sowing date. Since all characters showed reduced values, with delaying sowing date, the interaction effect

might be in the magnitude of reduction in each cultivar, with delaying sowing, from S₁ to S₂ and from S₂ to S₃. For example, in seed yield Nubaria 1, Nubaria 2, Giza 3 improved, Sakha 1 and Sakha 2 varieties showed a lower reduction in seed yield with delaying sowing from 22nd October to 7th November. Similar variations in magnitude of reduction achieved when delaying sowing date from 22nd October to 22nd November as well as, Nubaria 1, Nubaria 2, Sakha 1 and Sakha 2 varieties showed a lower reduction in seed yield with delaying sowing from 7th November to 22nd November. On the other hand, Giza 3 improved did not showed a lower reduction in seed yield with delaying sowing from 7th November to 22nd November. The present finding is confirmed with that of Sharaan *et al.* (2004), Osman *et al.* (2010), Bakry *et al.* (2011), Abd- El Hafez *et al.* (2012), Alazaki and Al –Shebani (2012) Attia *et al.* (2013) and Ibrahim (2016).

Effect the interaction among irrigation intervals x sowing dates x varieties

The data presented in Tables 7 showed the differences in all yield attributes and chemical analysis, due to the interaction among the three factors were significant. The highest values of pods and seeds weight/ plant were 57.04 and 45.32gm, as well as 100- seed weight (gm) and seed yield (ton/fed.) were 118.37 (gm) and 2.04 (ton/fed.) respectively, obtained by irrigation every 30 days (I₂) with early sowing (S₁) with Nubaria 1 variety (V₁). Generally, under the condition of this study, it could be recommended that irrigation every 30 days (I₂) with early sowing (S₁) and Nubaria 1 variety (V₁).

Table 4. Effect of the interaction between irrigation intervals and sowing dates and faba bean varieties on yield, yield attributes and chemical analysis interactions (combined analysis over two seasons).

Treatments	Plant height (cm)	Number of branches/ plant	height to 1 st pod	Number of pods/ plant	pods weight/pl ant (g)	Seeds weight /plant (g)	100_ seed weight (g)	seed yield (ton/fed.)*	straw yield (ton/fed.)*	Harvest index	protein %	Carbohydrate %	
Irrigation Intervals (I)	Sowing dates (S)												
I ₁	S ₁	99.21	2.58	36.78	10.56	36.81	29.27	97.14	1.90	3.44	35.72	24.48	48.57
	S ₂	88.65	2.36	28.36	10.46	37.81	27.49	94.64	1.78	3.41	34.98	24.53	46.31
	S ₃	74.14	1.61	20.18	9.50	30.56	23.98	92.13	1.75	2.51	41.66	26.90	45.29
I ₂	S ₁	102.69	2.75	38.32	10.90	40.24	30.79	96.52	1.91	3.77	34.75	25.92	46.80

	S ₂	82.40	2.22	27.85	9.86	35.73	26.69	95.45	1.83	3.13	36.99	24.47	44.95
	S ₃	71.57	1.40	19.74	8.26	26.14	19.61	94.66	1.61	2.64	37.67	25.17	43.08
	S ₁	106.82	3.07	36.47	12.11	43.82	33.24	95.22	1.93	3.88	33.64	24.89	44.92
I ₃	S ₂	82.70	2.43	26.37	10.42	34.92	27.16	92.21	1.79	3.31	35.49	26.01	42.62
	S ₃	69.66	1.54	20.61	8.05	26.75	21.16	94.51	1.61	2.61	39.00	25.54	42.14
	LSD _(5%)	1.25	0.105	1.28	0.26	1.42	1.13	1.47	0.033	0.242	2.11	0.071	0.506

*fed. = Feddan = 4200m²

Table 5. Effect of the interaction between irrigation intervals and faba bean varieties on yield, yield attributes and chemical analysis (combined analysis over two seasons).

Treatments		Plant height (cm)	Number of branches /plant	Height to 1 st pod	Number of pods/ plant	Pods weight /plant (g)	Seeds weight /plant (g)	100 Seed weight (g)	Seed yield (ton/fed.)*	Straw yield (ton/fed.)*	Harvest index	Protein %	Carbohydrate %
Irrigation Intervals (I)	Varieties (V)												
I ₁	V ₁	83.08	3.06	28.46	7.81	32.71	25.09	110.36	1.92	3.37	36.31	24.49	48.25
	V ₂	92.59	2.42	29.67	12.57	37.29	29.06	86.80	1.85	3.24	37.01	25.61	46.74
	V ₃	99.05	1.49	30.92	11.46	33.24	26.37	87.68	1.88	3.39	36.04	25.59	44.40
	V ₄	78.80	1.67	25.49	9.04	34.61	25.36	94.27	1.81	2.06	47.13	26.37	47.54
	V ₅	83.16	2.27	27.67	9.98	37.44	28.68	94.09	1.59	3.54	30.78	24.47	46.71
I ₂	V ₁	84.50	2.98	29.46	7.88	39.83	31.33	110.06	1.90	3.52	35.25	23.35	45.94
	V ₂	91.05	2.09	29.55	9.05	33.30	24.92	89.16	1.84	3.37	35.78	26.39	44.65
	V ₃	93.71	1.67	29.81	8.97	31.87	23.75	85.79	1.89	2.95	39.64	25.38	43.10
	V ₄	77.21	1.74	25.98	7.88	32.31	23.56	94.75	1.67	2.62	38.64	25.62	45.33
	V ₅	81.31	2.14	28.38	7.52	32.87	24.92	97.96	1.63	3.44	33.05	25.18	45.71
I ₃	V ₁	84.39	3.59	30.05	8.60	36.13	28.72	112.34	1.86	3.85	33.02	25.62	45.00
	V ₂	94.27	2.30	31.86	10.94	32.29	24.00	87.52	1.80	3.44	34.65	25.10	42.91
	V ₃	94.92	1.80	27.80	12.07	36.84	27.81	84.26	1.85	3.40	35.61	25.19	41.28
	V ₄	76.51	1.87	24.52	10.46	35.05	29.28	90.71	1.71	2.70	40.51	25.83	43.74
	V ₅	81.89	2.16	24.85	8.90	35.50	26.13	95.08	1.66	2.94	36.44	25.66	43.22
	LSD _(5%)	1.92	0.126	1.40	0.289	1.50	1.11	2.44	0.037	0.232	2.082	0.096	0.470

*fed. = Feddan = 4200m²

Table 6. Effect of the interaction between sowing dates and faba bean varieties on yield, yield attributes and chemical analysis (combined analysis over two seasons).

Treatments		Plant height (cm)	Number of branches /plant	Height to 1 st pod	Number of pods/ plant	Pods weight/ plant (g)	Seeds weight /plant (g)	100 Seed weight (g)	Seed yield (ton/fe d.)*	Straw yield (ton/fe d.)*	Harvest index	Protein %	Carbohydrate %
Sowing dates (S)	Varieties (V)												
S ₁	V ₁	99.44	2.74	39.58	8.81	43.70	35.39	116.66	2.02	4.33	31.76	24.84	48.23
	V ₂	109.81	2.09	39.32	13.14	40.25	30.08	88.43	1.98	4.10	32.50	24.73	46.98
	V ₃	117.29	2.17	39.99	13.36	41.09	31.59	84.63	2.00	3.83	34.62	25.21	44.80
	V ₄	90.82	2.80	32.37	10.17	36.13	28.36	93.86	1.85	2.71	40.86	26.23	47.35
	V ₅	97.20	2.74	34.69	10.48	40.28	30.06	97.89	1.73	3.51	33.79	24.47	46.46
S ₂	V ₁	81.66	2.29	29.01	8.10	35.16	26.64	112.96	1.91	3.67	34.33	22.85	46.07
	V ₂	90.34	1.74	28.99	11.82	35.41	26.38	87.75	1.85	3.43	35.56	25.71	44.48
	V ₃	92.71	1.90	28.36	11.72	35.16	26.76	87.12	1.88	3.49	35.18	25.03	42.53
	V ₄	77.40	2.17	24.68	10.47	38.69	28.59	89.54	1.73	2.48	40.80	25.92	44.74
	V ₅	80.81	2.29	26.60	9.12	36.33	27.21	93.13	1.63	3.35	33.24	25.51	45.32
S ₃	V ₁	70.87	1.78	19.38	8.47	29.82	23.10	103.13	1.75	2.75	38.49	25.77	44.88
	V ₂	77.76	1.13	22.77	9.55	27.22	21.52	87.29	1.66	2.52	39.39	26.67	42.84
	V ₃	77.67	1.21	20.17	9.40	25.69	19.59	85.98	1.74	2.42	41.49	25.91	41.45
	V ₄	64.31	1.60	18.95	7.63	27.15	21.26	96.32	1.61	2.19	44.62	25.66	44.52
	V ₅	68.36	1.78	19.60	7.96	29.19	22.45	96.12	1.53	3.07	33.23	25.33	43.86
	LSD _(5%)	1.921	0.126	1.400	0.289	1.507	1.114	2.448	0.037	0.232	2.082	0.096	0.470

* fed. = Feddan = 4200m²

Table 7. Effect of the interaction between irrigation intervals, sowing dates and faba bean varieties on yield, yield attributes and chemical analysis (combined analysis over two seasons).

Treatments			Plant height (cm)	No. of bran. /plant	height to 1 st pod	No. of pods/ plant	pods weight/ plant (g)	Seeds weight /plant (g)	100-seed weight (gm)	Seed yield (ton/ fed.)	Straw yield (ton/ fed.)	Harvest index	Protein %	Carbohydrate %
I	S	V												
I ₁	S ₁	V ₁	91.85	3.57	38.38	6.53	28.80	25.46	115.28	2.02	3.71	34.57	24.39	50.28
		V ₂	105.48	2.82	37.33	14.22	42.48	33.01	86.18	1.97	4.15	31.91	24.07	48.62
		V ₃	115.15	1.72	40.87	11.95	35.02	28.74	87.57	1.99	3.91	34.29	23.98	46.58
		V ₄	87.90	2.02	30.57	9.28	34.43	26.44	96.10	1.90	2.14	45.94	26.05	48.91
		V ₅	95.68	2.77	36.77	10.80	43.29	32.70	100.58	1.63	3.30	31.88	23.92	48.47
	S	V ₁	85.48	3.70	29.32	6.85	35.34	23.29	117.02	1.91	3.94	32.87	22.74	47.87

2	V ₂	93.22	2.55	28.38	12.33	37.33	28.24	88.90	1.80	3.18	36.27	25.31	45.52
	V ₃	102.77	1.53	30.68	13.15	37.53	29.30	86.68	1.86	3.72	33.32	24.78	44.30
	V ₄	81.75	1.82	26.90	10.62	42.23	29.49	91.43	1.77	2.31	43.39	25.91	46.66
	V ₅	80.03	2.18	26.50	9.33	36.59	27.12	89.17	1.59	3.92	29.07	23.91	47.21
	V ₁	71.90	1.90	17.67	10.03	33.98	26.51	98.77	1.83	2.48	41.47	26.34	46.60
S ₃	V ₂	79.07	1.88	23.28	11.15	32.06	25.92	85.32	1.79	2.4	42.84	27.45	46.07
	V ₃	79.23	1.22	21.20	9.27	27.17	21.08	88.78	1.80	2.55	40.50	28.00	42.32
	V ₄	66.75	1.17	19.02	7.23	27.15	20.15	95.27	1.76	1.73	52.07	27.13	47.05
	V ₅	73.77	1.87	19.73	9.80	32.43	26.22	92.52	1.57	3.41	31.40	25.59	44.44
	V ₁	104.67	4.18	41.00	10.83	57.04	45.32	118.37	2.04	4.58	30.71	25.15	47.98
S ₁	V ₂	110.37	2.68	38.52	12.58	41.03	30.16	91.50	2.01	4.34	31.70	25.91	46.95
	V ₃	119.12	2.00	42.42	12.98	38.42	28.59	81.35	2.04	3.60	36.45	25.54	45.11
	V ₄	87.52	2.17	32.67	9.25	33.09	24.21	94.03	1.76	2.57	40.81	27.12	47.47
	V ₅	91.80	2.73	36.98	8.87	31.62	25.65	97.33	1.73	3.78	34.08	25.86	46.48
	V ₁	78.95	3.02	28.22	8.20	36.33	28.33	106.88	1.95	3.26	37.19	21.15	45.81
I ₂	V ₂	85.42	1.97	29.15	11.38	33.95	25.36	90.10	1.93	3.30	37.83	26.50	44.94
	V ₃	83.63	2.02	27.25	10.92	34.70	25.82	91.58	1.94	3.21	37.86	24.43	43.30
	V ₄	79.08	1.85	25.97	9.15	35.39	25.72	90.67	1.68	2.49	39.27	25.26	44.85
	V ₅	84.90	2.27	28.65	9.63	38.27	28.25	98.03	1.65	3.38	32.81	25.01	45.84
	V ₁	69.88	1.75	19.17	7.88	26.13	20.32	104.92	1.70	2.72	37.87	23.76	44.01
S ₃	V ₂	77.37	1.63	20.98	9.05	24.91	19.23	85.87	1.57	2.47	37.82	26.76	42.04
	V ₃	78.37	1.00	19.75	8.97	22.48	16.85	84.45	1.69	2.0	44.59	26.18	40.88
	V ₄	65.02	1.20	19.30	7.88	28.45	20.77	99.55	1.57	2.82	35.82	24.46	43.67
	V ₅	67.23	1.42	19.50	7.52	28.72	20.87	98.52	1.53	3.17	32.24	24.67	44.81
	V ₁	101.80	4.85	39.35	9.05	45.27	35.40	116.33	1.99	4.71	29.99	24.98	46.44
S ₁	V ₂	113.57	2.72	42.10	12.63	37.23	27.05	87.60	1.95	3.82	33.88	24.19	45.35
	V ₃	117.60	2.57	36.70	15.13	49.83	37.44	84.97	1.98	3.98	33.11	26.13	42.72
	V ₄	97.03	2.32	33.87	11.97	40.85	34.44	91.45	1.89	3.43	35.83	25.51	45.67
	V ₅	104.12	2.90	30.33	11.77	45.94	31.84	95.75	1.82	3.45	35.41	23.64	44.43
	V ₁	80.55	4.02	29.48	9.25	33.80	28.28	114.98	1.86	3.8	32.94	24.66	44.53
I ₃	V ₂	92.38	2.37	29.43	11.75	34.94	25.54	84.26	1.83	3.82	32.58	25.31	42.97
	V ₃	91.73	1.67	27.13	11.10	33.25	25.18	83.10	1.84	3.54	34.34	25.89	40.00
	V ₄	71.35	2.03	21.17	11.63	38.45	30.55	86.53	1.74	2.65	39.74	26.59	42.71
	V ₅	77.48	2.05	24.65	8.38	34.13	26.27	92.18	1.67	2.73	37.86	27.61	42.89
	V ₁	70.83	1.92	21.32	7.50	29.33	22.48	105.70	1.72	3.04	36.13	27.22	44.03
S ₃	V ₂	76.85	1.82	24.05	8.45	24.70	19.40	90.70	1.63	2.69	37.50	25.80	40.41
	V ₃	75.42	1.17	19.57	9.97	27.43	20.82	84.70	1.72	2.67	39.38	23.54	41.13
	V ₄	61.15	1.27	18.53	7.77	25.84	22.85	94.15	1.50	2.02	45.95	25.38	42.82
	V ₅	64.07	1.52	19.57	6.55	26.43	20.27	97.32	1.49	2.63	36.05	25.74	42.33
	V ₁	80.55	4.02	29.48	9.25	33.80	28.28	114.98	1.86	3.8	32.94	24.66	44.53
LSD _(5%)		3.326	0.21 8	2.426	0.501	2.611	1.930	4.241	0.065	0.402	3.607	0.166	0.814

I= Irrigation Intervals, S= Sowing dates , V= varieties

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