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Some Agro-Physiological Studies on Faba Bean (*Vicia faba* L.)

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FIELD trials were conducted in a private farm (km 84 Cairo-Alex desert road) the to evaluate the productivity of two faba bean types differ in their growth habit (determinate and indeterminate) when grown with different row directions (N-S, E-W) and cropping patterns (quadrate and rectangular) . The results showed that faba bean sowing in the E-W direction significantly increased No. of branches and pods per plant than N-S sowing. Determinate faba bean plants significantly surpassed the indeterminate ones only in No of branches, and light energy flux density in the mid and under faba bean canopy while the indeterminate plans significantly exceeded the determinate type plants plant height and yield and its components as well as protein yield. Sowing faba bean in rectangle system seemed to be better and significantly increased growth and yield characters, *i.e.* dry matter of different plant parts , leaf area, illumination under faba bean canopy , No. of pods per plant . On the other hand , sowing faba bean in quadratic system significantly increased No. of seeds/ plant and 100-seeds weight. Although sowing faba bean in quadratic system surpassed the rectangle sowing by 10%; such increase was insignificant. Meanwhile, protein yield was significantly greater with quadratic sowing. The second and third order interaction among the studied factors were insignificant in most of the studied characters and did not reveal a clear attitude. It could be concluded from this study that faba bean plants were very sensitive to growth habit more than the spatial arrangement of the plants in the field. Moreover, the study indicated the importance of choosing the proper variety and cultural practices to increase faba bean yields without additional cost to the farmer.

Faba bean cropping area in Egypt is limited due to the competition with the major crop area occupied by berseem and wheat . Therefore, faba bean intensification is considered to be an approach to increase the productivity per unit area especially in the newly cultivated lands. The narrow row and plant sowing of faba bean have been found to increase the vertical productivity (El-Metwally, 1989, El-Fishawy & Fayed, 1990 and Zeidan, 1998). Under Egyptian condition, the dominant faba bean type grown is the indeterminate type which does not respond well to the intensification due to the greater canopy it has and yield reduction occurs as plant population increased (Hassanein *et al.*, 1997a) . Recently, The release of the new mutation of faba bean ; the top-less or the determinate faba bean has been attracted the attention to be grown at higher densities than the indeterminate faba bean type (Pilbeam *et al.*, 1991, Stutzel & Aufhammer, 1991 and Zeidan, 1998). The physiological performance of faba bean types was found to be sensitive to the variety and planting spaces; (Hassanein *et al.*, 1997b and Ziedan 1998).

Therefore, the aim of this work is to study the effect of row direction , growth habit and cropping system on two faba bean types differ in their growth habit on growth and yield in the newly reclaimed soil.

Material and Methods

Two field trials were conducted in a private farm (km 84 Cairo-Alex desert road), Egypt in two successive winter seasons of 2002 and 2003. The trials aimed to evaluate the productivity of two faba bean types differ in their growth habit when grown with different row directions and cropping patterns. The chemical analysis of the soil in both seasons are presented in Table 1 according to Jackson (1967).

TABLE 1. Chemical analysis of the experimental soil (Units: EC as dS m^{-1}; OM as %; other elements as mg kg^{-1})

Season	pH	EC	OM	N	P	K	Fe	Mn	Zn	Cu
2001/2002	7.96	0.21	1.11	1517	45.0	769	6737	73.4	10.3	4.25
2002/2003	7.91	0.24	1.34	1587	46.7	798	6002	64.6	12.9	4.88

The experiment included 8 treatments which were the combinations of two row direction sowing (East- West and North –South) and two faba bean types i.e; determinate (FLIP 87 -117 strain , released by ICARDA) and indeterminate type (Var. G461 released by ARC; Minst. of Agric, Egypt) as well as two cropping patterns Qadratic (20x20 cm) and rectangle (10x40 cm). The experimental design was split-split plot desigin with four replications.

The experimental soil was ploughed twice, ridged and divided into experimental unites 21 m^2. Then the phosphatic fertilizer was applied as calcium super phosphate at 31kg P_2O_5. Both faba bean types were sown in two row directions; East-West (E-W) and North –South (N-S).Cropping systems were Quadratic (20x20 cm) and Rectangle (40x10 cm). Sowing was applied on November 8^{th} and 11^{th} in both seasons, respectively. Faba bean seeds were inoculated with the specific rhizobium strain and the seeds immediately sown in the planned manner. Nitrogen fertilizer was applied in two equal doses at 21 and 35 days from sowing at rate of 60 kg N fed^{-1}as ammonium nitrate (33.5 % N) . Potassic fertilizer was applied at rate of 48 kg K_2O fed^{-1}. Weeds were controlled manually after 18 and 32 days of sowing.

Faba bean plants flowered (50% of the plants) after 45 and 50 days from sowing in 2001/2002 and 2002/2003 seasons, respectively. At early pod formation ten plants were taken from each plot to detrmine plant height, number of branches, leaves, above-ground biomass weight, Leaf area / plant (LA) and leaf area index (LAI). Light intensity was measured in the mid and under faba bean canopies using lux meter according to and then the measurements were converted to Light Energy Flux Density as described by Milthorpe and Moorby (1979) according to the relationship

$1\ wm^{-2} = 111.8lux = 1jm^{-2}\ sec^{-2}$ where w : watte J : joule

Total nitrogen content was determined by the standard procedures described by Nelson and Sommers (1980). Then N-content was multiplied by 6.25 to calculate protein percentage in order to calculate protein yield per feddan. P was determined by spectrophotometery and K was determined by using flame emission photometry (Jackson, 1967). Micronutrients were determined using atomic absorption spectrophotometer in dry ash digestion (Chapman and Pratte , 1978). The data were subjected to the proper statistical analysis as described by Gomez and Gomez (1984). Since the data in both seasons took similar trends, Bartlett's test was applied and the combined analysis of the data was done; for means comparison Least Significant Difference (LSD) test was applied at 5% level.

Results and Discussion

Effect of row direction

Data presented in Table 2 show that with the exception for plant height and No. of pods per plant the other faba bean studied characters did not significantly affected by sowing either in N-S or E-W row directions. In general , sowing faba bean in E-W direction increased plant height, dry matter accumulation per plant, LA, LAI, light energy flux density in the mid- canopy as well as yield traits i.e.; No. of pods/plant, No. of seeds/pod, seed yield per plant and per feddan. Clarke *et al.* (2000) concluded that if rows are oriented east–west with winter wheat spring wheat field trials with plots differing for height may have less competitive for light and better growth occured . Dan Krie (2001) stated that East-West row direction allows the incident radiation to strike the soil surface between the rows all day long. This should result in greater evaporation of rainfall from the bare soil and less of the total water supply available for the crop to use. The plants within-the-row shade each other resulting in less water demand because of less energy being absorbed by the canopy. The North-South row direction provides just the opposite set of conditions

Effect of faba bean growth habit

Data presented in Table 3 show that the determinate faba bean plants significantly surpassed the indeterminate ones in No. of branches/plant, light energy flux density in the mid and under faba bean canopies . On contrast, the indeterminate type plants significantly exceeded the determinate plants in yield traits *i.e.*; No of pods/plant, 100-seeds weight and seed yield per plant and per feddan.The superiority of determinate faba bean in No. of branches could be attributed to the growth habit which lead to form more branches than the indeterminate type plants (Zeidan, 1998). On contrast, the indeterminate plants surpassed the determinate ones in most growth and yield characters due to the its taller plants ,greater canopy which led to more photosynthate formed and greater and heavier pods, seeds produced per plant and per area. Similar results were obtained by Pilbeam *et al.* (1991) and Hassanein *et al.* (1997b).

TABLE 2. Effect of row direction on faba bean growth and yield characters

Character	Row Direction		Significance	LSD0.05
	N-S	E-W		
Plant height	88.1b	90.8a	N.S	N.S
No. of branches /plant	3.21a	3.03b	*	0.62
Dry matter of stem g/plant	3.53a	3.47a	N.S	N.S
Dry matter of leaves g/plant	3.06a	3.22a	N.S	N.S
Total dry matter g/plant	6.53a	6.76a	N.S	N.S
Leaf area dm^2/plant	12.38a	13.04a	N.S	N.S
Leaf area index (LAI)/plant	3.09a	3.26a	N.S	N.S
Light energy flux density in the mid canopy ($kJcm^{-2}Sec^{-1}$)	889.8a	948.8a	N.S	N.S
Light energy flux density under the canopy ($kJcm^{-2}Sec^{-1}$)	306.7a	251.4a	N.S	N.S
No. of pods/ plant	13.84b	15.66a	*	0.58
No. of seeds / plant	25.54a	27.72a	N.S	N.S
100-seed weight (g)	73.24a	72.08a	N.S	N.S
Seed weight g/ plant	11.97a	13.08a	N.S	N.S
Seed yield ton/ fed	1.257a	1.373a	N.S	N.S
Seed yield Ardab/ fed	7.85a	8.58a	N.S	N.S
Protein yield kg/ fed	328.4	376.7	N.S	N.S

(N-S) = North –South
(E-W) = East-West

Effect of cropping Pattern

Data in Table 4 show that sowing faba bean plants in the rectangle pattern significantly exceeded the quadrate sowing pattern in No. of branches /plant , dry matter accumulation of different plant parts, leaf area and LAI, light energy flux density under faba bean canopy and No. of pods/plant. However, the quadrate pattern planting significantly surpassed the rectangle pattern in No. of seeds / plant and 100-seed weight. Seed yield per plant and per feddan was greater with the quadrate pattern compared with the rectangle pattern. Abou El Zahab *et al* (1981) found that seed yield per unit area as the inter- row and intra row spacing approached a uniform (square) distribution (30x 30 cm) . They concloded that square rather than rectangular arrangements of plants would improve the efficiency of utilization light , water and nutrients available to individual plants on an area basis. Also square plant distribution may delay the overlapping of leaves and the competition on light which reflects on the obtained criteria of growth characters like plant height , branching , dry matter accumulation and light energy flux density. In addition , yield component characters especially No of pods and seeds/plant100- seed weight and protein yield.

TABLE 3. Effect of growth habit on faba bean growth and yield characters.

Character	Growth Habit		Significance	LSD0.05
	Determinate	Indeterminate		
Plant height	79.18	99.82	**	2.69
No. of branches /plant	3.61a	2.63b	*	0.62
Dry matter of stem g/plant	3.45a	3.55a	N.S	N.S
Dry matter of leaves g/plant	3.06a	3.19a	N.S	N.S
Total dry matter g/plant	6.51a	6.65a	N.S	N.S
Leaf area dm^2/plant	12.9a	12.51a	N.S	N.S
Leaf area index (LAI)/plant	3.22a	3.13a	N.S	N.S
Light energy flux density in the mid canopy ($kJcm^{-2}Sec^{-1}$)	1002.9a	835.8b	**	90.6
Light energy flux density under the canopy ($kJcm^{-2}Sec^{-1}$)	403.1a	224b	***	87.41
No. of pods/ plant	12.91b	16.59a	***	0.59
No. of seeds / plant	25.94a	27.32a	N.S	N.S
100-seed weight (g)	71.53b	73.79a	*	1.87
Seed weight g/ plant	10.92b	14.13a	***	1.45
Seed yield ton/ fed	1.146b	1.483a	***	0.151
Seed yield Ardab/ fed	7.17b	9.27a	***	0.94
Protein yield kg/fed	335.92	413.4	**	17.4

TABLE 4. Effect of cropping system on faba bean growth and yield characters.

Character	Cropping System		Significance	LSD 0.05
	Quadrate	Rectangle		
Plant height	90.81a	88.2a	N.S	-
No. of branches /plant	2.67b	3.56a	**	0.56
Dry matter of stem g/plant	3.38b	3.61a	*	0.11
Dry matter of leaves g/plant	2.93b	3.36a	**	0.3
Total dry matter g/plant	6.31b	6.98a	***	0.31
Leaf area dm^2/plant	11.85b	13.57a	**	1.2
Leaf area index (LAI)/plant	2.96b	3.39a	**	0.29
Light energy flux density in the mid canopy ($kJcm^{-2}Sec^{-1}$)	909.5b	929.5a	N.S	N.S
Light energy flux density under the canopy ($kJcm^{-2}Sec^{-1}$)	224b	334.1a	*	87.4
No. of pods/ plant	13.58b	15.92a	***	0.58
No. of seeds / plant	29.11a	24.14b	**	2.74
100-seed weight (g)	74.06a	71.26b	**	1.87
Seed weight g/ plant	13.19a	11.68b	N.S	N.S
Seed yield ton/ fed	1.385a	1.244a	N.S	N.S
Seed yield Ardab/ fed	8.65a	7.78a	N.S	N.S
Protein yield kg/fed	390.7	314.11	*	17.4

The interaction effects

Data presented in Tables (5 & 6) show that the second order interaction (row direction x faba bean type) ; row direction x cropping pattern and (faba bean type x cropping pattern as well as the third order interaction (row direction x faba bean type x cropping pattern) on growth and yield characters. The statistical analysis of the data showed that most of the interactions were insignificant. However, the interaction between row direction and faba bean type on plant height; while the interaction between row direction and cropping pattern significantly affected light energy flux density in the upper and lower faba bean canopy heights and number of pods /plant. At the same time No. of pods /plant significantly affected by the interaction between faba bean type and cropping pattern. The third order interaction was only significant on No. of seeds/plant.

Seed chemical constituents

Data presented in Table 7 show that non of the main factors studied significantly affected faba bean chemical composition of seeds. Both faba bean types were similar in macro and micronutrients contents also sowing faba bean in quadrate or rectangle pattern did not affect seed composition .Similarly, sowing direction did not reveal significant effects on faba bean content. These results are in harmony with those obtained by Hassanein *et al.* (1997b) and Zeidan (1998).

It could be concluded from this study that faba bean plants were very sensitive to growth habit. Indeterminate faba bean types are considered to be more favored for the Egyptian agriculture more than the determinate faba bean ones for its greater yielding. In addition the spatial arrangement of the plants in the field under intensification should be chosen carefully. Moreover, the study indicated the importance of choosing the proper faba bean type and cultural practices to increase faba bean yields without additional cost to the farmer.

TABLE. 5 Effect of second and third order interactions on growth characters.

Row Direction (A)	Faba Bean Type (B)		Plant height cm	DM of Leaves/ Plant (g)	DM of Stems/ plant (g)	No. of Branches/ plant	Total DM / plant (g)	Leaf Area dm^2 / plant	LAI/ plant	Light Energy Flux Density ($kJcm^{-2}Sec^{-1}$) In the mid canopy	Light Energy Flux Density(kJcm-2Sec-1) under the canopy)
(AxB)											
E-W	Determinate		72.88	3.09	3.47	3.43	6.56	12.47	3.12	1053.38	565.36
	Indeterminate		103.34	3.04	3.46	2.99	6.50	12.27	3.07	726.26	48.088
N-S	Determinate		85.46	3.30	3.43	3.81	6.73	13.32	3.33	952.38	240.75
	Indeterminate		96.30	3.16	3.64	2.26	6.79	12.76	3.19	945.24	262.00
LSD 0.05			NS	NS	NS	NS	NS	NS	NS	NS	NS
(AxC)											
Row Direction(A)	Cropping System(C)										
E-W	Quadrate		85.98	2.88	3.38	2.50	6.26	11.63	2.91	892.25	230.93
	Rectangle		90.25	3.25	3.56	3.91	6.80	13.11	3.28	887.39	382.53
N-S	Quadrate		95.64	2.99	3.39	2.88	6.37	12.05	3.01	925.92	217.09
	Rectangle		86.13	3.47	3.68	3.20	7.15	14.02	3.51	971.69	285.66
LSD 0.05			2.69	NS	NS	NS	NS	NS	NS	76.50	87.40
(BxC)											
Determinate	Quadrate		80.05	2.92	3.31	3.18	6.23	11.79	2.95	976.43	312.95
	Rectangle		78.30	3.48	3.59	4.06	7.05	14.00	3.50	1029.33	493.16
Indeterminate	Quadrate		101.56	2.95	3.45	2.20	6.39	11.90	2.98	841.75	135.06
	Rectangle		98.08	3.25	3.65	3.05	6.90	13.13	3.28	829.75	175.03
LSD 0.05			NS	NS	NS	NS	NS	NS	NS	NS	NS
(AxBxC)											
E-W	Determinate	Quadrate	71.63	2.83	3.36	2.65	6.18	1142.31	2.86	1038.95	408.95
		Rectangle	74.15	3.35	3.59	4.20	6.94	1353.4	3.38	1067.8	721.775
	Indeterminate	Quadrate	100.33	2.93	3.40	2.35	6.33	1184.73	2.96	745.55	52.9
		Rectangle	106.35	3.14	3.53	3.63	6.67	1269.57	3.17	706.975	43.275
N-S	Determinate	Quadrate	88.48	3.01	3.27	3.70	6.28	1216.04	3.04	913.9	216.95
		Rectangle	82.45	3.59	3.59	3.93	7.17	1448.34	3.63	990.85	264.55
	Indeterminate	Quadrate	102.80	2.96	3.50	2.05	6.46	1195.84	2.99	937.95	217.225
		Rectangle	89.80	3.36	3.78	2.48	7.13	1356.43	3.39	952.525	306.775
LSD 0.05			NS	NS	NS	NS	NS	NS	NS	NS	NS

TABLE. 6 Effect of second and third order interactions on yield characters.

Row Direction (A)	Faba Bean Type(B)		Pod no./pl	Seed no./plant	100-seed wt (g)	SeedY/ plant(g)	SeedY /f(ardab)
			Ax B				
E-W	Determinate		11.6	25.81	72.44	10.04	6.59
	Indeterminate		16.01	25.26	74.05	13.90	9.12
N-S	Determinate		14.22	26.06	70.61	11.80	7.74
	Indeterminate		17.10	29.38	73.54	14.35	9.42
LSD0.05			NS	NS	NS	NS	NS
Row Direction	Cropping System(C)						
			AxC				
E-W	Quadrate		12.69	28.35	74.93	12.41	8.15
	Rectangle		14.99	22.73	71.56	11.53	7.56
N-S	Quadrate		14.48	29.88	73.20	13.96	9.16
	Rectangle		16.85	25.56	70.95	12.19	8.0
LSD0.05			0.58	NS	NS	NS	NS
			BxC				
Determinate	Quadrate		12.08	28.25	72.95	11.54	7.57
	Rectangle		13.75	23.63	70.10	10.30	6.76
Indeterminate	Quadrate		15.09	29.98	75.18	14.84	9.74
	Rectangle		18.09	24.66	72.41	13.41	8.80
LSD0.05			0.46	NS	NS	NS	NS
			AxBxC				
E-W	Determinate	Quadrate	10.88	29.25	74.9	10.73	7.038
		Rectangle	12.33	22.38	69.98	9.35	6.14
	Indeterminate	Quadrate	14.50	27.45	74.95	14.10	9.25
		Rectangle	17.65	23.08	73.15	13.70	9.0
N-S	Determinate	Quadrate	13.28	27.25	71.00	12.35	8.10
		Rectangle	15.18	24.88	70.23	11.25	7.38
	Indeterminate	Quadrate	15.68	32.50	75.40	15.58	10.22
		Rectangle	18.53	26.25	71.68	13.13	8.61
LSD0.05			NS	1.74	NS	NS	NS

TABLE 7. Chemical composition of faba bean seed (Units: macronutrients N, P and K as %; other elements as mg kg^{-1}).

Treatment	N	P	K	Fe	Mn	Zn	Cu
Row Direction							
N-S	4.18	0.37	0.97	69.6	7.94	28.2	3.83
E-W	4.39	0.39	1.07	65.0	8.21	22.0	3.65
Faba bean Type							
Determinate	4.69	0.44	0.99	81.7	7.73	25.1	3.75
Indeterminate	4.46	0.34	1.04	73.4	7.62	20.1	4.00
Cropping Pattern							
Quadrate	4.34	0.37	1.03	56.4	7.63	19.9	3.92
Rectangle	4.04	0.36	1.05	47.6	6.99	27.8	3.00

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بعض الدراسات الزراعية الفسيولوجية على الفول البلدى

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قسم بحوث المحاصيل الحقلية – المركز القومي للبحوث– القاهرة – مصر.

أقيمت تجربتان حقليتان في الموسمين الزراعيين ٢٠٠١/ ٢٠٠٢ و ٢٠٠٢/ ٢٠٠٣ بأحدى المزارع الخاصه بالكيلو ٨٤ طريق مصر الاسكندرية الصحراوي لدراسة تأثير اتجاه التخطيط (شمال– جنوب) او(شرق –غرب). ونظم الزراعة على شكل مستطيلات (٤٠×١٠) أو مربعات على مسافة (٢٠×٢٠) سم على نمو و محصول الفول البلدي المحدود وغير المحدود النمو واستخدم فىالتجربة تصميم القطع المنشقة مرتين فى أربعة مكررات وخلال موسم النمو تم دراسة صفات ارتفاع النبات و عدد الأوراق والوزن الجاف للاوراق والسيقان والنبات الكامل ومساحة الاوراق ديسيمتر[٢]/ نبات ودليل مساحة الأوراق وكثافة انسياب الطاقة الضوئية (ميجا جول /سم[٢]/ثانية) فى وسط واسفل الكتلة الحيوية للفول البلدى كما تم دراسة المحصول ومكوناته وأجرى التحليل الكيماوى لبذور الفول لتقدير العناصر الكبرى والصغرى وتم حساب محصول البروتين للفدان لكلا الصنفين

وتشير النتائج إلى أن زراعة الفول البلدى بنظام التسطير (شرق–غرب) أدى إلى زيادة معنوية في كل من عدد الأفرع وعدد القرون/ نبات مقارنة بنظام التسطير(شمال– جنوب) كما أن طراز الفول البلدى محدود النموتفوق معنويا على الطراز غير المحدود فى كثافة انسياب الطاقة الضوئية فى وسط واسفل

الكتلة الحيوية للفول البلدى فى حين تفوق الفول غير المحدود النمو معنوياً فى صفات ارتفاع النبات والمحصول ومكوناته ومحصول البروتين للفدان

كما تشير النتائج إلى أن زراعة الفول البلدى بنظام المستطيلات (١٠×٤٠) كانت افضل من الزراعة على هيئة مربعات (٢٠×٢٠) وادت الى زيادة معنوية في صفات النمو والمحصول مثل الوزن الجاف لاجزاء النبات المختلفة ومساحة الاوراق وكثافة انسياب الطاقة الضوئية أسفل الكتلة الحيوية وعدد القرون/ نبات فى حين أدت زراعة الفول البلدى على هيئة مربعات إلى زيادة معنوية فى عدد البذور /نبات ووزن١٠٠بذرة وعلى الرغم من تفوق محصول الزراعة فى مستطيلات على محصول الزراعة على هيئة مربعات بحوالى١٠ % تقريبا إلا أن هذه الزيادة لم تكن معنوية كما تفوق محصول البروتين للفدان معنوياً عند الزراعة على هيئة مستطيلات وبالنسبة للتفاعلات الثنائية والثلاثية بين عوامل الدراسة فكانت قليلة ولم تصل إلى حد المعنوية فى معظم الصفات المدروسة

ويستنتج من التجربة أن نباتات الفول البلدى كانت أكثر حساسية و تأثراً بطبيعة النمو بدرجة أكبر من طرق التسطير ونظم هندسة توزيع النباتات بالحقل كما تشير الدراسة ايضا الى اهمية اختيار الصنف والعمليات الزراعية المناسبة والتي من شأنها أن تؤدي إلى زيادة النمو والمحصول دون تكلفة إضافية للمزارع.