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EFFECT OF PLANT POPULATION AND DISTRIBUTION ON YIELD AND YIELD COMPONENTS OF FIVE FABA BEAN GENOTYPES

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ABSTRACT

Plant population density plays an important role on crop growth and yield as response to light penetration and photosynthesis rate. A field experiment was carried out at Sids Research Station, Agricultural Research Center (ARC), during two successive winter seasons, of 2012/13 and 2013/14. The objectives of this investigation was aimed to evaluate five faba bean genotypes namely Nubaria 1(large seeded cultivar), Giza 429, line 43130, E.19 (medium seeded types) in addition to the small seeded type Camolina. Plant densities were; a) 8 plants/m^2 planted in single seeded hills spaced 20 cm on one side of 60 cm wide ridges, b) 17 plants/m^2 planted in double seeded hills spaced 20 cm on one side of the ridges, c) 17 plants/m^2 planted in single seeded hills spaced 20 cm on both sides of the ridges and d) 33 plants/m^2 planted in double seeded hills spaced 20 cm on both sides of the ridges. Results indicated that, faba bean genotypes were significantly different in all studied characters. Nubaria 1 and E.19 genotypes had the tallest plants, respectively. The highest seed yield per feddan was obtained from Nubaria 1 cultivar, while the medium seeded line L-43130 produced the lowest seed yield per feddan over both seasons. Giza 429 (medium seeded cultivar) followed by Nubaria 1. Plant population of 17 plants/m^2 in single seeded hills on both sides of the ridges produced highest seed yield per feddan over all genotypes. Concerning to the interaction between plant populations and faba bean genotypes, highest seed yield per feddan was obtained from the large seeded cultivar Nubaria 1 under the low plant population (8 plants/m^2), while the medium seeded types *i.e.* Giza 429, L-43130 and E19 were more yielding under the third plant population (17 plants/m^2 on both sides of the ridge). On the other hand, the small seed type Camolina produced highest seed yield per feddan under the high plant population (33 plants/m^2). The interaction between faba bean genotypes and plant population had significant effects on all studied characters except number of days to flowering.

Keywords: Faba bean (*Vicia faba* L.), Genotypes, Plant population and distribution, Seed Size

INTRODUCTION

Faba bean (*Vicia faba* L.) is one of the most important legume crops for human consumption in Egypt as a protein source. It plays an essential role in enhancing soil fertility. Also, production of faba bean is still limited and falls to face the increasing local consumption of the crop; this is related to the low cultivated area, which decreased dramatically in last decade due to the strong competition between faba bean and other strategic winter crops such as wheat and clover in Nile valley and Delta. Faba bean production is affected by different factors such as genotypes, plant distribution and plant density, (Amer, 1986; El-Shazly and Nassr, 1989; Bakry *et al*., 2011; and

Khalil *et al* 2011). Plant density is one of the important factors which affect crop growth and yield by its impact on the efficiency of plant absorbing nutrients and utilizing the environmental factors. Many authors studied the effect of plant density of faba bean on growth, yield and its components. (Al-Rifaee, 1999; Tawaha and Turk, 2001; Turk and Tawaha, 2002 and Thalji, 2006).

Low plant density may result in low yield, more weed infestation and poor light-use efficiency; however, high plant density can cause lodging, less light penetration in the crop canopy, reduced photosynthetic efficiency and consequently seed yield reduction (Jettner *et al.,* 1998). Divergent studies on the effect of plant density on faba bean traits were conducted by various researchers (Abo-Shetaia, 1990; EL-Habbak and EL-Naggar, 1993; EL-Douby *et al.,* 1996), who indicated that increases in plant density decreased numbers of pods and seed yield/plant, as well as 100-seed weight, but insignificantly increased seed yield/fed, compared to the recommended density. Optimal density to achieve maximum yield depends on genetic characteristics of hybrid, and also water and nutrients requirements. However, it is a general principle that if appropriate number of plants is not used in the unit of land in fact the available potential has not been used optimally.

In more plant distribution, as the rate of photosynthesis increases and assimilated are produced the pods have more potential to produce seeds and since the pods are formed in lower heights, The present work aimed to investigate the response of five faba bean genotypes to different plant population densities in Middle Egypt.

MATERIALS AND METHODS

Two field experiments were carried out at Sids Research Station, Agricultural Research Center (ARC), during two successive winter seasons of 2012/13 and 2013/14. The objectives of this research was to evaluate five faba bean genotypes under four plant populations. Planting date was conducted during first half of November in both seasons. Five faba bean genotypes (Table 1) namely; Nubaria 1 (large seeded type), Giza 429, line 43130 and E.19 (medium seeded type) and Camolina (small seeded type).

Table 1.The pedigree and origin of the five faba bean studied genotypes

Genotype	Pedigree	Origin
Nubaria 1	Individual plant selection from Reina Blanca	Egypt
Giza 429	An individual plant selection from Giza 402	Egypt
L-43130	F7/8992/05 Xsel2004latt.393-1	ICARDA
E. 19	HBP/ S0 F /2003, Fam. 75/WH (FLIP08-020FB)	ICARDA
Camolina	Spanish genotype	Spain

Plant populations and distribution were conducted as follows:

a) 8 plants/m^2 obtained by planting one side of the ridge in one seeded hill.
b) 17 plants/m^2 obtained by planting one side of the ridge in double seeded hills.

c) 17 plants/m^2 obtained by planting both sides of the ridge in one seeded hill.
d) 33 plants/m^2 obtained by planting both sides of the ridge in double seeded hills.

The experiment was conducted in split-plot design with three replications. The different genotypes were arranged in the main plots and plant populations and distribution were assigned to sub plots. Each experimental plot was 7.2 m^2 (four ridges 60 cm width and 3 m long), and 20 cm hill spacing.

Recommended cultural procedures for commercial faba bean production were applied. At harvest time, five guarded plants were taken at random from the inner ridges and data of days to flowering, days to maturity, plant height (cm), number of branches/plant, number of pods/plant, seed yield/plant (g), 100-seed weight (g) and seed yield (ard/fed.) were recorded (ardab = 155kg and feddan = 4200m^2).

Data were subjected to the proper statistical analysis of the technique of analysis of variances (ANOVA) of split plot design as mentioned by **Steel and** Torrie (1980). Treatment means were compared with the Least Significant Difference (LSD) test at 0.05, and analyzed the combined analysis for both seasons.

RESULTS AND DISCUSSION

Effect of Genotypes:

Combined data presented in Table 2 clearly showed that faba bean genotypes differed significantly in all studied characters. Results presented in Table 2 revealed that, plant height was significantly affected by different genotypes; E.19 and Nubaria 1 genotypes had the tallest plants (109.6 and 108.7 cm. respectively). Similar results were reported by Khalil, *et al*. (2011) who found that faba bean cultivars differed in their plant height. The number of branches per plant was significantly affected by different genotypes where Nubaria 1 and L-43130 genotypes recorded highest number of branches (5.8 and 5.6, respectively).

Table 2. Means of seed yield and its attributes as affected by studied faba bean genotypes (combined of both seasons)

Characters / Genotypes	Days to flowering (No.)	Days to maturity (No.)	Plant height (cm)	No. of branches/ plant	No. of pods/ plant	Seed yield/ plant (g)	100 seed weight (g)	Seed yield ard./fed
Nubaria 1	67.1	156.4	108.7	5.8	26.8	91.8	115.0	14.02
Giza 429	52.7	145.7	101.7	4.9	38.3	107.5	86.2	13.79
L.43130	62.8	147.2	102.2	5.6	33.1	85.6	80.6	10.85
E19	58.8	150.1	109.6	4.9	39.8	106.3	83.5	13.37
Camolina	40.3	136.5	81.9	3.4	44.9	51.5	39.7	13.38
$LSD_{0.05}$:	0.61	0.64	4.54	0.48	4.73	12.10	3.05	0.77

Highest number of pods per plant was achieved by Camolina cultivar (44.9) while the lowest value was obtained from Nubaria 1 cultivar (26.8). Giza 429 and E.19 genotypes gave highest seed yield per plant (107.5 and

106.3 g, respectively). However, Nubaria 1 cultivar produced highest seed yield ard/fed. (14.02), due to heavy 100-seed weight (115.0 g). The significant differences for all characters may be due to the different genetical make up which effects the growth habit. These results are in agreement with those obtained by Silim and Saxena,1992 and Al Ghamdi, 2007,who reported significant differences among faba bean varieties concerning seed yields and its components. Number of days to flowering and maturity were significantly affected by genotypes; Camolina showed the earliest flowering and maturing plants while the delayed genotype was Nubaria 1.

Effect of plant population and distribution:

Results in Table 3 showed that there were significant differences between studied plant populations and distribution in all studied characters.

Results presented in Table 3 clearly indicated that highest plant population (d = 33 plants/m^2) had the tallest plants (104.7 cm), along with earliness for flowering and maturity 55.5 and 146.6 days, respectively. Earliness in flowering and maturity was related to high plant population (33 plants/m^2).

Table 3. Effect of plant population and distribution on seed yield and its components of faba bean genotypes (combined data of 2012/13 and 2013/14 seasons)

Characters / plant distribution	Days to flowering (No.)	Days to maturity (No.)	Plant height (cm)	No. of branches/ plant	No. of pods/plant	Seed yield/plant (g)	100 seed weight (g)	Seed yield ard./fed
8 plants/m^2	57.3	147.1	98.4	5.9	37.8	94.9	82.5	13.68
17 plants/m2	55.9	147.4	100.5	4.4	35.8	84.3	79.9	12.43
17 plants/m2	56.7	147.6	99.7	5.5	38.7	98.1	81.1	13.83
33 plants/m2	55.5	146.6	104.7	3.9	34.1	76.9	80.5	12.38
$LSD_{0.05}$:	0.65	0.52	2.61	0.33	2.58	5.48	1.50	0.46

On the other hand, highest number of branches per plant and the heaviest 100-seed weight were (g) related to low plant population (a = 8 plants/m^2). However, the plant population 17 plants/m^2 (both sides of the ridge with one seeded hill) recorded highest number of pods/plant (38.7), seed yield/plant (98.1g) and seed yield ard/fed. (13.83). The increase in these traits may be attributed to the decrease in number of plants/m^2 which in turn increased metabolites synthezed due to less competition between plants in the same unit area. These results are in accordance with those obtained by Darwish and Hassanin, 1991, Amer *et al.*, 1992, Salwau, 1994 and Al-Rifaee, 1999.

Effect of the interaction between genotype and plant population and distribution:

Combined data in Table (4) showed that the interaction between faba bean genotypes and plant population and distribution had significant effect on all studied characters except number of days to flowering.

Results presented in Table 4 clearly indicated that highest number of branches, number of pods, seed yield/plant, 100-seed weight and seed yield ard/fed were obtained at low plant population density for Nubaria 1 and

recorded 8.3, 33.7, 111.3 (g), 120.6 (g) and 16.44, respectively. However, Giza 429, L43130 and E.19 genotypes had the tallest plants by increasing plant population to 33 plants/m^2 and recorded 107.5, 116.7 and 112.5 respectively, while the highest values of number of branches, number of pods, seed yield/plant, 100-seed weight and seed yield per feddan of these medium seeded types were obtained from 17 plants/m^2 distributed on both sides of the ridges with single seeded hills.

Table 4. Effect of the interaction between five faba bean genotypes and four plant populations on seed yield and its components (combined data of 2012/13 and 2013/14 seasons).

Genotype	Characters / plant population	Days to flowering	Days to maturity	Plant height (cm)	No. of branches/ Plant	No. of pods/ plant	Seed yield/ plant (g)	100 seed weight (g)	Seed yield ard./fed
Nubaria 1	8 plants/m^2	67.5	155.8	104.4	8.3	33.7	111.3	120.6	16.44
	17 plants/m2	66.5	155.7	113.6	5.6	26.1	93.4	113.3	15.46
	17 plants/m2	67.7	156.8	105.8	5.3	26.6	92.6	115.2	12.24
	33 plants/m2	66.8	157.3	111.1	4.2	20.7	69.8	111.0	11.82
Giza 429	8 plants/m^2	53.2	145.3	97.8	6.7	43.7	122.0	89.1	14.55
	17 plants/m2	52.7	146.5	103.9	4.7	32.0	83.8	85.8	12.77
	17 plants/m2	53.2	146.2	97.5	4.7	45.3	133.7	86.1	15.24
	33 plants/m2	51.8	145.0	107.5	3.8	32.3	90.7	83.7	12.62
L.43130	8 plants/m^2	63.3	147.3	96.4	6.0	33.3	79.5	81.9	10.76
	17 plants/m2	63.0	148.3	91.7	4.8	31.3	84.2	78.9	10.81
	17 plants/m2	63.3	147.7	104.2	6.9	39.0	102.7	83.4	12.11
	33 plants/m2	61.3	145.7	116.7	4.8	28.7	76.2	78.4	9.71
E19	8 plants/m^2	60.2	150.2	107.5	5.3	39.8	110.5	82.9	12.48
	17 plants/m2	57.3	149.2	111.7	4.0	39.7	104.8	84.2	14.51
	17 plants/m2	59.0	151.5	106.7	6.3	42.5	116.3	87.1	14.83
	33 plants/m2	58.8	149.7	112.5	4.0	37.3	93.7	79.9	11.70
Camolina	8 plants/m^2	42.2	137.3	85.8	3.3	35.7	45.3	39.9	11.52
	17 plants/m2	40.3	137.5	81.7	3.0	50.0	54.2	39.6	12.08
	17 plants/m2	40.3	135.8	84.2	4.2	42.5	51.0	39.5	14.59
	33 plants/m2	38.7	135.3	75.8	3.0	51.5	55.3	40.0	15.32
$LSD_{0.05}$:		**NS**	**1.2**	**5.8**	**0.7**	**5.8**	**12.2**	**3.3**	**1.0**

On the other hand, number of pods, seed yield per plant, 100-seed weight and seed yield ard/fed. for Camolina genotype were significantly increased by increasing plant population up to 33 plants/m^2, also in high density number of days to flowering and maturity were decreased. This phenomenon may be related to the high competition between plants and plants hurry to finish their life cycle. These results were similar to findings reported by Stringi *et al.* (1986), Singh *et al.* (1992) and Turk and Tawaha (2002).

CONCLUSION

From the previous results, it could be concluded that, to obtain maximum seed yield from the large seeded cultivar Nubaria 1, it should be planted with the low plant population (8 plants/m^2) distributed in single seeded hills on one side of the ridges, while the small seeded type Camolina is more yielding with increasing plant population up to 33 plants/m^2 distributed in both sides of the ridges in doubled seeded hills. However, the medium seeded types such Giza 429 cultivar responded more to the medium plant population (17 plants/m^2) distributed on both sides of the ridges with single seeded hills.

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تأثير الكثافة والتوزيعات النباتية على المحصول ومكوناته لخمسة تراكيب وراثية من الفول البلدى

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أجريت تجربتان حقليتان بمحطة بحوث سدس - مركز البحوث الزراعية - خلال الموسميين الزراعين ٢٠١٣/٢٠١٢ و٢٠١٤/٢٠١٣ بهدف تقييم خمسة تراكيب وراثية من الفول البلدى وهى نوبارية ١ (بذرة كبيرة الحجم)، جيزة ٤٢٩ وسلالة ٤٣١٣٠ وسلالة ١٩ (بذرة متوسطة الحجم) بالإضافة الى الصنف كامولينا ذو البذور الصغيرة الحجم. والعامل الثاني اشتمل على أربع كثافات وتوزيعات نباتية كما يلى :-

أ- ٨ نباتات/م^{٢} حيث تتم الزراعة بوضع بذرة واحدة بالجورة على مسافة ٢٠سم بين الجور على ريشة واحدة وعرض الخط ٦٠سم.
ب- ١٧ نبات/م^{٢} حيث تتم الزراعة بوضع بذرتين بالجورة على مسافة ٢٠سم بين الجور على ريشة واحدة وعرض الخط ٦٠سم.
ج- ١٧ نبات/م^{٢} حيث تتم الزراعة بوضع بذرة واحدة بالجورة على مسافة ٢٠سم بين الجور والزراعة على الريشتين وعرض الخط ٦٠سم.
د- ٣٣ نبات/م^{٢} حيث تتم الزراعة بوضع بذرتين بالجورة على مسافة ٢٠سم بين الجور والزراعة على الريشتين وعرض الخط ٦٠سم.

ويمكن تلخيص أهم النتائج فيما يلى:-

١- أوضحت النتائج أن التراكيب الوراثية المستخدمة من الفول البلدى اختلفت معنويا فى جميع الصفات المدروسة. وقد سجل كل من الصنف نوبارية ١، سلالة ١٩ أطول نباتات (١٠٨,٧، ١٠٩,٦سم) على التوالى. كما أعطى الصنف نوبارية ١ أعلى محصول (١٤,٠٢ أردب/فدان) فى حين أعطت السلالة ٤٣١٣٠ (المتوسطة الحجم) أقل محصولاً (١٠,٨٥ أردب/فدان) على مستوى الموسميين. وقد أعطى الصنف جيزة ٤٢٩ (متوسط الحجم) والصنف نوبارية ١ محصولاً قدره (١٣,٧٩، ١٤,٠٢ أردب/فدان) على التوالي.
٢- أشارت النتائج أن الزراعة بالكثافة النباتية ١٧ نبات/م^{٢} وذلك بوضع بذرة واحدة بالجورة على مسافة ٢٠سم بين الجور على الريشتين وعرض الخط ٦٠ سم أعلى محصولاً للفدان وذلك لجميع التراكيب الوراثية المستخدمة.
٣- أظهر التفاعل بين الكثافات النباتية والتراكيب الوراثية من الفول البلدي أن أعلى محصول كان عند استخدام الصنف نوبارية ١ ذو البذور الكبيرة الحجم والكثافة النباتية ٨ نباتات/م^{٢} فى حين أن التراكيب الوراثية متوسطة الحجم (جيزة ٤٢٩، سلالة ٤٣١٣٠ وسلالة ١٩) سجلوا محصولاً أعلى تحت الكثافة النباتية ١٧ نبات/م^{٢} على الريشتين وأعطى الصنف كامولينا ذو البذور الصغيرة الحجم ١٥,٣٢ أردب للفدان تخت الكثافة النباتية ٣٣ نبات/م^{٢}.
٤- أشارت النتائج أن التفاعل بين التراكيب الوراثية من الفول البلدى والكثافة النباتية ذو تأثير معنوى لجميع الصفات المدروسة ماعد صفة عدد الأيام من الزراعة حتى التزهير.