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Diversity of Growth and Yield Parameters of Seven *Vicia faba* L. Genotypes

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ABSTRACT

Growth and yield parameters, as well as protein content, were used to elucidate the intraspecific diversity of seven faba bean genotypes (*Vicia faba* L. (2n=12)) and to search for selection criteria for plant breeding. With a few exceptions, the majority of parameters showed significant variability between the seven genotypes tested: root length, leaf fresh and dry weights, number and weight of nodules, protein content, flower number, aborted flower number, pod number, seed number/pod and fertility index. Protein content was positively correlated with seed number/pod and root length, but negatively correlated with the date of maturity. Line 20104, of Syrian origin, was the most important genotype since it had the most precocious maturity date (164.25 days), the highest protein content (39.76%), the highest number of seeds/pod (2.28) and the greatest yield (37.73 g). Local genotype 1 also showed good yield (37.53 g). Line 20301 provided the most pods/plant (14.81). These ideotypes will be very useful for faba bean breeding programs for which a plant breeding model has been proposed.

Keywords: dendrogram, growth parameters, protein content, *Vicia faba* L., yield parameters

Abbreviations: AFN/P, aborted flower number/plant; **BN/P**, branch number/plant; **FD**, flowering date; **FI**, fertility index; **FN/P**, flower number/plant; **Fluo7**, fluorescence in level 7 beginning from the apex; **Fluo9**, fluorescence in level 9 beginning from the apex; **SN/P**, seed number/pod; **H**, plant height; **LA**, leaf area; **LDW/P**, leaf dry weight/plant; **LFW/P**, leaf fresh weight/plant; **LN/P**, leaf number/plant; **MD**, maturity date; **NN/P**, number of nodules/plant; **NW/P**, nodule weight/plant; **PC**, protein content; **PN/P**, pod number/plant; **RL**, root length; **Y/P**, yield/plant

INTRODUCTION

The leguminous family (Fabaceae) is characterized by very wide diversity. It includes about 600 genera with 17,000 enumerated species of grain plants (Walter *et al.* 2001). Leguminous plants fix atmospheric nitrogen (N), which represents 78% of air, and convert it to organic N, useful to plants (Trinchant *et al.* 1997). In fact, leguminous roots form a symbiosis with soil bacteria, principally of the *Rhizobium* genus (Perret *et al.* 2000). This family enriches the soil with N by improving the earth's quality and decreasing the use of fertilizers. Due to these characteristics, plants are rotated with cereals. *Vicia faba* L. is one of the most cultivated leguminous species in the world and in Tunisia. Its characteristics are suitable for sustainable agriculture (Nadal *et al.* 2003). This species is a partially cross-pollinated crop while many factors, such as pollinator abundance (Suso *et al.* 2001) and floral and inflorescence characteristics (Suso *et al.* 2005), influence the out-crossing rate among different faba bean genotypes or different plants within the same genotype.

V. faba is a considerable source of energy (Duke 1981; Bond *et al.* 1985): 344 Kcal/100 g. The protein content of this species varies from 25 to 30% (Bond *et al.* 1976) and can efficiently replace animal protein in poor countries.

High yield, smaller seeds, few anti-nutritional factors, and high adaptability to modern agriculture makes this plant more attractive to farmers, feed and food manufacturers (Duc 1997).

According to Rowlands (1955), the main *V. faba* yield components are: pod number/plant; seed number/pod and seed size. Likewise, Keller and BeUucci (1980) and Pandey (1981) confirmed the central role of pod number/plant as the primary yield component.

In contrast, Picard and Berthelem (1980) indicated that seed weight was the most valuable yield component as a selection criterion for potential yield and yield stability. On the other hand, Magyarosi and Sjodin (1976) and De Vries (1981) both reported significant positive correlations between yield and seed number/pod, leading these authors to suggest that seed number/pod had a direct effect on yield in faba bean. In addition to yield components, many parameters could describe the yield structure of crops such as total dry matter production and fertility index (Donald and Hamblin 1976; McVetty and Evans 1980).

To best exploit the genetic diversity of *V. faba*, the present investigation was undertaken to determinate the selection criteria of quality, growth and yield parameters.

MATERIALS AND METHODS

Plant material

Seven *V. faba* genotypes were used for this study. Their origin and pedigree are summarised in **Table 1**.

Experiment

The experiment was conducted at the Higher Agronomic Institute during the 2004/2005 season. The genotypes were randomized in four blocks with five replicates (i.e. pots) each.

For the N biological fixation study, three plants per plot for each genotype were uprooted during the flowering stage. At maturity, the remaining plants were uprooted to study the yield components.

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Table 1 Origin of studied populations.

Genotype N°	Variety	Pedigree	Origin	Abbreviation
Land race 1	*major*	–	Unknown	G1
Land race 2	*equina*	–	Unknown	G2
Land race 3	*minor*	–	Unknown	G3
Introduced line 20104	*minor*	Syrian local large	Syria	G4
Introduced line 20203	*minor*	20 Crosses (Latin America)	ICARDA	G5
Introduced line 20301	*minor*	10 Crosses (Virus, disease resistance)	ICARDA	G6
Introduced line 20202	*minor*	14 Crosses (Cold et disease resistance)	ICARDA	G7

Recorded data

The flowering date (FD) and maturity date (MD) were measured for each genotype. The growth parameters, including chlorophyll fluorescence, which permits the study of photosynthetic yield, in two leaf stages (Fluo7), (Fluo9), leaf number/plant (LN/P), leaf area (LA) (cm^2), leaf fresh weight/plant (LFW/P) (g), leaf dry weight/plant (LDW/P) (g), number of nodules/plant (NN/P), nodule weight/plant (NW/P) (g) and root length (RL) (cm) were recorded during the flowering stage.

Yield parameters, including plant height (H) (cm), branch number/plant (BN/P), number of flowers/plant (FN/P), number of aborted flowers/plant (AFN/P), pod number/plant (PN/P), seed number/pod (SN/P) (g), fertility index (FI) and yield/plant (Y/P) (g) were recorded during the beginning of the maturity stage.

For protein content (PC) determination, leaves were randomly sampled from each experimental plant at a rate of one leaf from each leaf stage. Collected samples were dried separately in a drying oven at 68°C for 48 h, and ground using a laboratory mill with a 0.5 mm sieve. All samples were analyzed for N content using a modified micro-Kjeldahl digestion procedure (Bremmer and Mulvaney 1982). Crude PC was then computed by multiplying total N by a factor of 6.25 (Balman and Smith 1993):

N%= V/P*10 with N%: N level in % of dried material

V: Volume of titration solution

P: assay sample (g)

% protein= %N*6.25

Statistical analysis

All data were subjected to statistical analysis using SPSS (Statistical Package for the Social Sciences) according to Sticksel *et al.* (2000). Each determination was carried out on three separate samples and analyzed in triplicate. The results were then averaged. Data were assessed by analysis of variance (ANOVA). Duncan's multiple range test was used to separate the means. Means were significantly different at $P \leq 0.05$. The same software was used to check the correlation coefficients between the 20 studied parameters.

Ascendant hierarchic classification by aggregation method permits the determination of homogeneity between the genotypes. A dendrogram was established based on Euclidian distances between the seven genotypes using the same SPSS software.

RESULTS

There were significant differences in flowering and maturity date among the 7 genotypes (**Table 2**).

Table 2 Flowering and maturity dates.

Populations	FD	MD
G1	62.00 d	175.00 a
G2	705.00 d	170.75 b
G3	65.50 c	165.50 cd
G4	64.25 b	164.25 d
G5	65.50 a	165.50 cd
G6	67.00 a	167.00 c
G7	70.00 a	170.00 b

Values followed by the same letter in a column are not significantly different at P<0.05 according to DMRT.
See text for list of abbreviations.

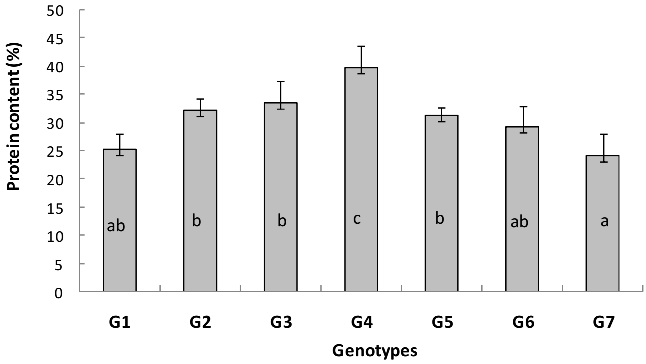

Fig. 1 The percentage of protein content (%) for the 7 faba bean genotypes. Bars with the same letter are not significantly different ($P < 0.05$).

Growth parameters

Data presented in **Table 3** shows that there were no significant differences for the parameters Fluo7, Fluo9, LN/P and LA between faba bean genotypes.

Nevertheless, the five remaining parameters (RL, FWL/P, DWL/P, NN/P, and NW/P) showed significant differences.

Protein content

PC showed wide and significant variability between the 7 genotypes. G4 showed the highest while G7 showed the lowest PC value (**Fig. 1**).

Yield and its related parameters

Data of the measured vegetative growth parameters of *V. faba* plants are presented in **Table 4**. H, BN/P and Y/P did not show significant variability among the 7 genotypes tested.

However, genotypes differed significantly in five other parameters: FN/P, AbFN/P, PN/P, SN/P and FI.

Hierarchical and ascending classification with aggregation methods

Based on 7 of the studied parameters (H, BN/P, MD, FD, PC, PN/P, SN/P), and in order to assess the degree of relationship between the 7 genotypes, a hierarchical and ascen-

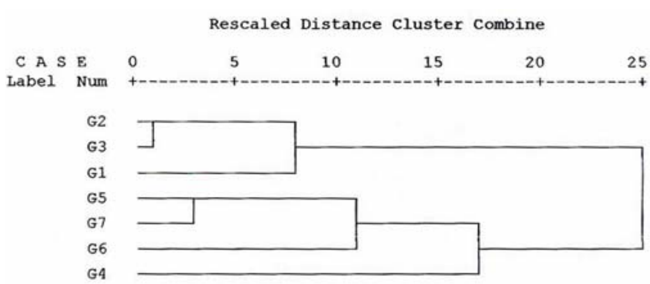

Fig. 2 Dendrogram shown genetic relationships (using hierarchical cluster analysis) between the 7 faba bean genotypes.

Table 3 Growth parameters.

	Fluo7	Fluo9	LN/P	LA (cm^2)	LFW/P (g)	LDW/P (g)	NN/P	NW/P (g)	RL (cm)
G1	0.83 a	0.82 a	253.41 a	1825.74 a	55.68 a	4.44 ab	276.25 a	2.73 a	35.00 b
G2	0.81 a	0.82 a	234.66 a	1900.36 a	56.09 a	4.23 ab	238.50 ab	2.46 a	43.00 ab
G3	0.81 a	0.82 a	187.50 a	1817.47 a	48.69 ab	5.01 a	179.62 ab	1.87 ab	44.00 ab
G4	0.79 a	0.81 a	223.91 a	1796.47 a	45.73 ab	4.52 ab	172.75 ab	1.69 ab	49.00 a
G5	0.80 a	0.81 a	306.91 a	1705.12 a	38.38 b	3.54 b	199.12 ab	2.04 ab	33.33 b
G6	0.83 a	0.82 a	225.50 a	1715.98 a	44.38 a	4.44 ab	105.87 ab	1.43 ab	35.00 b
G7	0.82 a	0.81 a	309.58 a	1570.93 a	40.97 b	3.37 b	63.37 b	0.92 b	40.33 ab

Values followed by the same letter in a column are not significantly different at P<0.05 according to DMRT.
See text for list of abbreviations.

Table 4 Yield parameters.

	H (cm)	BN/P	FN/P	AbFN/P	PN/P	SN/P	FI	Y/P (g)
G1	84.25 a	7.00 a	58.09 ab	48.09 a	10.16 ab	1.43 b	0.16 b	37.53 a
G2	84.41 a	7.41 a	60.17 ab	51.25 a	8.91 b	1.71 ab	0.16 b	31.29 a
G3	80.00 a	5.58 a	63.58 a	54.75 a	8.83 b	2.02 ab	0.14 b	27.82 a
G4	85.91 a	6.08 a	63.58 a	52.00 a	11.58 ab	2.28 a	0.19 ab	37.73 a
G5	91.25 a	7.16 a	41.50 b	28.41 b	13.08 ab	1.76 ab	0.47 a	30.31 a
G6	78.00 a	5.33 a	46.36 ab	31.54 b	14.81 a	1.96 ab	0.35 ab	29.99 a
G7	87.33 a	6.41 a	62.58 a	49.16 a	13.41 ab	1.90 ab	0.31 ab	31.96 a

Values followed by the same letter in a column are not significantly different at P<0.05 according to DMRT.
See text for list of abbreviations.

ding classification was done based on Nei's (1978) genetic distance, which yielded three major clusters (**Fig. 2**): Cluster I (G1, G2, G3), Cluster II (G5, G6, G7 with similar Y/P and PC), and Cluster III (G4, with highest Y/P and PC).

DISCUSSION

Based on the data obtained, 13 of the 20 studied parameters presented significant variability between the 7 genotypes. Polignano *et al.* (1999) used a large collection of faba bean (1565 entries from 39 countries) from the Bari Germplasm Institute to describe the phenotypic diversity according to 10 traits (flower colour, stem colour, leaflet shape, leaflet size, pod density, pod distribution, plant height, pod angle, flowers/raceme, pods/node).

The variability of studied parameters according to genotypes

The FD of studied genotypes varied from 65 to 77 days. G1 and G2 showed precocious FD (65 days). In fact, under a semi-arid climate, precocity plays an important role in escaping dryness (Sedgley 1991; Loss and Siddique 1997). Another study done by Turk *et al.* (2002) showed that the FD of *V. faba* (minor) was ~79 days. Sadiki *et al.* (2002a) showed that Moroccan faba bean genotypes needed 87 days for flowering and Chenna (1998) indicated that some Algerian genotypes required, on average, 29.86 days. To avoid damage, which could be caused by freezing in late spring, the dryness and high temperatures characterizing the Mediterranean climate, some plants flower precociously (Smith *et al.* 1995). Açıkgöz (2001) affirmed that low temperatures delayed FD in *Vicia* genus.

The most precocious MD was registered by G4 (162.25 days) while last MD was shown by G1 (175 days). This variability could be due to the fact that the grains of *V. faba major* are clearly larger than those of *V. faba minor.* Consequently, filling and hardness needed more time resulting in late maturity. Such variability was also observed in some Algerian late genotypes (Chenna 1998) and in some more precocious Moroccan genotypes (Sadiki *et al.* 2002a).

Studying growth parameters provides information about a genotype's adaptation to assay conditions. RL showed considerable variability between genotypes. According to Rolfe *et al.* (1997), the root system varied depending on the species, even within the same legumes and cereals species and on environmental conditions.

LA and LN/P did not show any significant variability between genotypes. Mwanamwenge (1999) found that these parameters were not significantly different in three *V. faba* genotypes ('ACC286', 'Fiord' and 'Icarus'). In contrast, Ahmad *et al.* (2007) affirmed that there were significant differences depending on the genotype for these parameters when studying 'Giza-Blanka' and 'Giza-483'.

In contrast, LFW/P and the LDW/P showed significant variability. This result may provide information about photosynthetic activity which depends on the foliage. Oren *et al.* (1989) proved there is a high correlation between photosynthetic rate and leaf weight for conifers.

NN/P and NW/P showed wide variability and provide information about the affinity of *Rhizobium* to each genotype. Variation in symbiotic capacity of legumes species and cultivars and consequently the nodulation dependence on genotypes is not a new concept (Ballard *et al.* 2000; Hsayaoui 2002; Drew and Ballard 2010).

The PC of the genotypes studied was different. Faba bean is known for its wealth of protein (25-35% of dry matter) (Bond *et al.* 1976). The quality of grain is probably strongly linked to the genotype. The PC in faba beans ranged, depending on the genotype, between 27 and 34% of seed dry matter (Duc 1997).

Yield parameters showed considerable fluctuation. H of the 7 genotypes was similar. Sadiki *et al.* (2002b) and Sifi *et al.* (2002) showed that H was not significant for the same *V. faba* genotypes. However, H is considered to be a genotype-dependent parameter (Magda and Shalaby 2000). During harvest, this parameter plays an important role in the reduction of yield loss. In fact, short genotypes are more difficult to harvest mechanically than tall genotypes.

BN/P showed no significant variability, which confirmed the results obtained for three *V. faba* genotypes (Mwanamwenge 1999).

PN/P and SN/P are two parameters that play a very important role in crop improvement programs. G6 showed the highest PN/P value. These results agree with those found for faba bean by Hassanein (2000) and Sifi *et al.* (2002). Sabh and Shallan (2008) found a lower PN/P for *V. faba* cv. 'Assiut 86'. The variation was more accentuated between *V. faba minor* and *V. faba major* genotypes. SN/P varied between the 7 genotypes, although the highest value was shown by G4. Sadiki *et al.* (2002a) studied the variability for the same species from the Maghreb collection (161 lines accessions) and demonstrated variability in this parameter. Accordingly, Bond *et al.* (1985) confirmed that faba bean genotype determines the seed number/plant.

In contrast to Sadiki *et al.* (2002b)'s studies on *V. faba* genotypes which registered a very significant difference, the variance analysis of Y/P did not show any significant variability among our studied genotypes. The same results could be explained by the soil type, inadequate fertilization, shelling loss and infrequent watering. Bago *et al*. (1987) affirmed that *V. faba* Y/P is the result of many components such as sowing density, PN/P, and grain weight.

Interaction between different measured parameters

1. Flowering and maturity dates

FD and MD expressed no significant correlation coefficients with Y/P. In contrast, an assay done on *Vicia* showed that Y/P had a positive correlation with FD (Yücel 2004). However, Anlarsal *et al*. (1999) affirmed that the correlation was negative because the plants were affected by low temperature during flowering.

In contrast, FD showed significant positive correlations with AFN/P and FI (r = 0.399 and 0.432, respectively). In fact, the later the FD is, the greater the reduction in AFN/P and the higher the FI. Similarly, if the plant flowers late, it will be more fruitful, and flowering precocity probably influences fructification negatively. In this case, G5 presented the latest FD; however, it showed a Y/P comparable to the other genotypes.

The FD showed high significant negative correlation coefficients with most of the growth parameters; LA, FLW/P, DLW/P, and NW/P with r = -0.429, -0.569, -0.379 and -0.481, respectively. Otherwise, when FD is precocious the LA, FLW/P, DLW/P and NW/P values are higher. This result proved the role played by these parameters (factors) in flowering precocity. In fact, the more vigorous a plant is, the more precocious flowering is; photosynthesis and nitrogen fixation could be two determinant factors of flowering precocity.

During grain filling, carbon provisioning is principally based on photosynthesis, and N assimilation and symbiotic fixation decrease during this period (Salon *et al.* 2001). The correlation coefficient linking FD and MD was significantly high (r = -0.518) indicating that the later FD is the more precocious maturity is. A significant negative correlation between FD and MD was noted for *Vicia marbonensis* L. (Siddique 1996). MD showed a strong correlation with SN/P (r = -0.630). These results prove that the lower SN/P is the later maturity is reached. *V. faba minor*, which contains numerous small grains, reached maturity before *V. faba major*, which is characterized by big and fewer grains. In our assay, G1 showed the lowest SN/P and latest MD.

2. Yield and growth parameters

Y/P did not express any significant correlation with growth parameters. In contrast, these parameters showed complex relationships among themselves. LN/P was positively and significantly correlated with BN/P and H: r = 0.720 and 0.263, respectively. NN/P showed a positive and significant correlation with leaves, LFW/P and LDW/P: r = 0.416, 0.379 and 0.297, respectively. NW/P expressed a unique correlation with LA (r = 0.303). These results were analogous to those obtained for genotypes of *Phaseolus vulgaris* L., indicating that good nodulation genotypes possess higher dimension and dry weight of aerial parts (Hsayaoui 2002).

3. Yield and protein content

There was a positive and significant correlation between Y/P and PC: r = 0.426. In fact, the higher the value of Y/P the more protein-rich the plant is. This result is in contrast to the results found for legumes (Erskine *et al.* 1985; Vollmann *et al.* 2000; Tokatlidis *et al.* 2004); these authors claimed that PC is generally inversely correlated to Y/P.

PC also expressed a positive and highly significant correlation (r = 0.724) with SN/P. The higher the SN/P value, the richer the protein content of a plant is.

A correlation between PC and some growth parameters was detected. RL was positively and significantly correlated with PC (r = 0.419). Probably, RL influenced PC, permitting a very intense absorption of soil nutritive elements. PC, being directly linked to N levels in the plant, was suspected to have a positive and significant correlation with NN/P (Asimi *et al.* 1980) but the obtained result did not confirm this hypothesis. The low correlations between PC and NN/P and NW/P could be assigned to the lack of efficient *Rhizobium* strain. Moreover, a study by Gabsi (1992) on *Phaseolus vulgaris* L. showed that the correlation between NN/P and the N level was not always positive, and depended on the genotype. PC was inversely correlated to MD (r = -0.578). In general, the later the maturity date of the plant, the poorer it is in protein. This proved the important effect of climatic conditions on grain quality. When sowing in the field, the precocity of G3, G4 and G5 will permit them to escape dryness of the final month of cultivation which affects grain quality.

4. Yield and its related parameters

The correlations between Y/P and related components permit us to have a clearer idea about the component which should be improved. In fact, Y/P showed a positive and

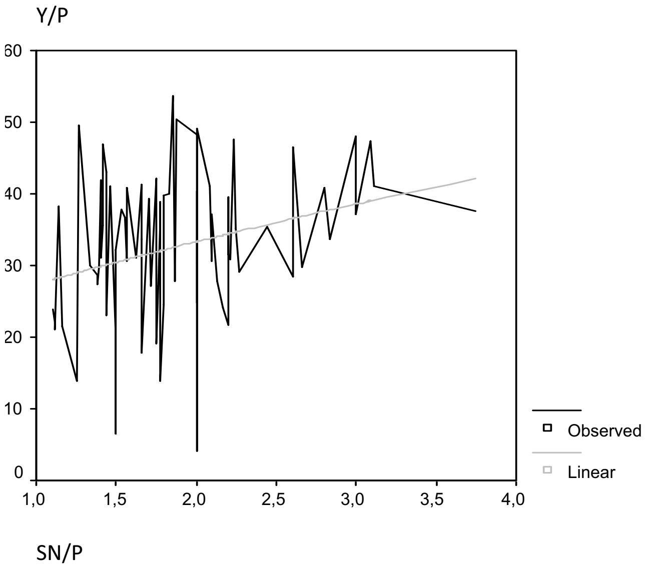

Fig. 3 Correlation between Y/P and SN/P (r = 0.238).

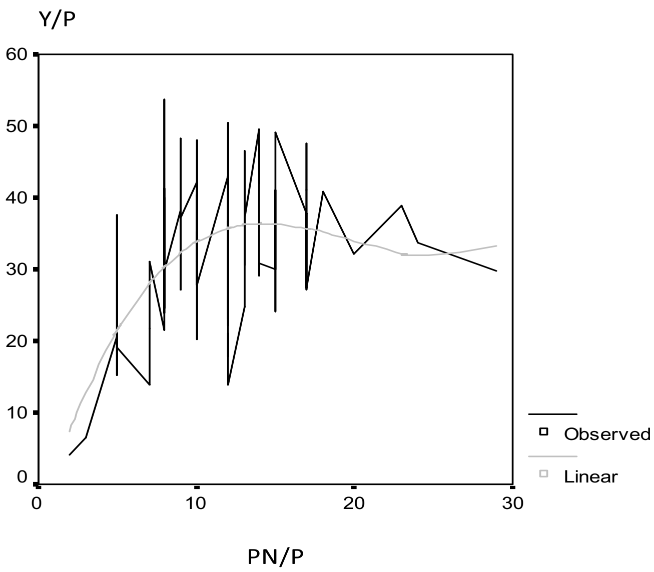

Fig. 4 Correlation between Y/P and PN/P (r = 0.328).

significant correlation with PN/P and the SN/P (r = 0.328 and 0.283, respectively; **Figs. 3, 4**). Two curves were plotted to clarify the exact nature of these correlations. The correlation curve between Y/P and PN/P was comparable to a linear equation while that between Y/P and SN/P was comparable to a cubic equation. This could signify that the increase of PN/P always amplifies Y/P, when the positive influence of SN/P is limited.

PN/P is dependent on plant fertility: when SN/P shows an in increase in the number of fecund ovules this will result in strong competition for grain filling. So, when smaller grain is obtained the yield will be reduced.

Analogous studies on *V. faba* effectively displayed that Y/P was positively and significantly correlated with PN/P and SN/P (Sindhu *et al.* 1985; Bakheit and Mahdy 1988; Nigem *et al.* 1990).

FI was highly and significantly correlated with some yield components such as FN/P, AFN/P and PN/P (r = -0.634, -0.729 and 0.582, respectively. This showed that the higher the value of FN/P and AFN/P are the lower is the value of FI. Chbouki *et al.* (2005) formulated that the quantitative differences of AFN/P in three physiological types of *V. faba* are due to different physiological reactions that result in internal competition for resources.

Competition between flowers is probably the origin of the high level of abortion in genotypes with many flowers. Gates *et al.* (1983) confirmed that competition for assimilation of mineral elements exists between vegetative and reproductive faba bean plant parts. FI is negatively and significantly correlated with BN/P (r = -0.229). The higher the value of BN/P, the lower the value of FI. During faba bean development, the branches also compete for nutritive elements with young pods (Stützel and Aufhammer 1991).

The correlation coefficients between FI and most growth parameters were not significant and were all negative (**Table 5**); this confirms the notion of competition between vegetative growth and yield, once again confirming the theory of Gates *et al.* (1983).

NN/P showed a positive correlation with FN/P and PN/P. Analogous results were obtained by Nuňerz *et al.* (2005). Thus, biological N fixation could be in favor of leguminous fructification. *V. faba* yield is the result of many components: genotype, sowing date, sowing density, PN/P, SN/P and the mean weight of grain (Bago *et al.* 1987).

CONCLUSION

Genotype 4 (20104) and local genotype 1 showed good yields (37.73 g) and (37.53 g), clearly higher than the other genotypes. These two genotypes showed similar pod PN/P. Genotype G4 (20104) also showed highest PC (39.76%).

Genotype G4 had positive correlations between Y/P and some of its components (PN/P and SN/P), while PC showed a correlation with some parameters (MD and Y/P). These correlations should be studied by breeders and should be considered during an improvement programme.

According to this study, a model faba bean ideotype could be proposed for Tunisian semi-arid regions: A high PN/P, an important FI, a precocious MD, deep roots, efficient nodulation, an intermediate BN/P, an important LA, a tall plant.

Table 5 Correlation coefficients between the measured parameters (part 1).

	Y/P	SN/P	FI	PN/P	MD	PC	RL	NW/P	NN/P
Y/P	1								
SN/P	0.283*	1							
FI	0.076	-0.117	1						
PN/P	0.328*	-0.122	0.582**	1					
MD	0.026	-0.630**	-0.242	-0.173	1				
PC	0.426*	0.724**	0.032	-0.042	-0.578**	1			
RL	0.273	0.534**	-0.266	-0.096	-0.281	0.419*	1		
NW/P	0.037	-0.186	0.002	-0.027	0.347	0.067	0.096	1	
NN/P	0.164	-0.098	-0.034	-0.094	0.134	0.154	0.325	0.874**	1
LDW/P	-0.023	-0.01	-0.202	-0.080	-0.016	0.232	0.519**	0.138	0.297*
LFW/P	-0.06	-0.174	-0.256	-0.172	0.303	0.058	0.402*	0.206	0.379**
LA	-0.035	-0.158	-0.138	-0.122	0.139	0.117	0.468*	0.303*	0.379**
Fluo9	-0.081	-0.169	-0.454**	0.006	-0.048	-0.410*	-0.362	-0.081	0.416**
Fluo7	-0.043	0.026	-0.072	-0.123	0.094	0.194	-0.357	-0.075	-0.027
AbFN/P	-0.112	0.071	-0.729**	-0.398**	0.261	-0.148	0.254	-0.099	-0.058
FN/P	-0.039	0.046	-0.634**	-0.172	0.247	-0.186	0.264	-0.115	-0.108
H	0.161	-0.093	0.023	0.074	-0.195	-0.073	-0.150	0.075	0.127
LN/P	-0.064	-0.068	-0.021	0.145	0.284	-0.356	-0.246	0.052	0.036
BN/P	-0.073	-0.198	-0.229*	0.01	0.247	-0.096	-0.118	0.244	-0.118
FD	-0.277	0.165	0.432**	0.365	-0.518**	-0.025	-0.147	-0.481**	-0.360

Values followed by * show a positive correlation between parameters.
Values followed by ** show a highly positive correlation between parameters.
See text for list of abbreviations.

Table 5 Correlation coefficients between the measured parameters (part 2).

	LDW/P	LFW/P	LA	Fluo9	Fluo7	AbFN/P	FN/P	H	LN/P	BN/P	FD
LDW/P	1										
LFW/P	0.794**	1									
LA	0.810**	0.843**	1								
Fluo9	0.193	0.174	-0.073	1							
Fluo7	0.021	0.101	-0.001	0.213	1						
AbFN/P	0.096	0.194	0.057	0.357**	-0.005	1					
FN/P	0.081	0.162	0.029	0.385**	-0.038	0.972**	1				
H	-0.084	0.027	0.076	0.09	0.12	-0.081	-0.067	1			
LN/P	-0.114	-0.013	0.047	-0.091	0.075	0.026	0.065	0.263*	1		
BN/P	0.003	0.095	0.116	0.008	0.101	0.174	0.189	0.181	0.720**	1	
FD	-0.379*	-0.569**	-0.429*	0.059	0.086	-0.399*	-0.348	0.164	0.1	-0.190	1

Values followed by * show a positive correlation between parameters.
Values followed by ** show a highly positive correlation between parameters.
See text for list of abbreviations.

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