Phenotypic diversity among faba bean (*Vicia faba*) local genotypes in Albania

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Abstract

Though broad bean is not actually a crop of a high significance for Albanian agriculture, its use is constantly increased. Hence there is also an increased interest of identification of best genotypes in terms of yield, protein content and biomass. For that purpose, seeds of 12 different genotypes received from Albanian Genetic Bank were sown in pyramidal foam trays filled with peat and kept in a non-heated greenhouse. After the first true leaves were appeared the seedlings were transplanted; half in the same greenhouse and the next half in open field nearby. 20 plants were transplanted for each genotype in a single line, either in greenhouse, or in open field. The characterization and evaluation of genetic and phenotypic diversity of selected genotypes was conducted according to the respective IBGRI descriptors. Significant phenotypic variation was found among locally grown Albanian faba bean genotypes. The highest variability was found regarding branching from basal nodes, height of lowest pod-bearing node, days to flowering, number of flowers inflorescence^{-1}, number of pods node^{-1}, number of seeds pod^{-1} and the weight of 100 seeds. The respective traits could be valuable for further breeding of best suited local commercial cultivars.

Keywords: genotype, branching, leaf, flower, pod, seeds

INTRODUCTION

The faba bean is an ancient crop. Plant traces of this species have been associated with early crop domestication in archaeological deposits of the Stone, Bronze and Iron Ages in the Near East and Mediterranean basin: in Spain, Italy, France, Switzerland and Germany. The name faba originates from one of the forms of the Greek verb *wagev* (to eat) which highlights its use for food and feed by the ancient Greeks and Romans (Duc et al., 2010).

Faba bean (*Vicia faba* L.), also referred to as broad bean or field bean, is one of the oldest crops grown by humans and is a valuable protein-rich food and animal feed (Duc, 1997). It is widely considered as a good source of protein, starch, cellulose and minerals for humans in developing countries and for animals in industrialized countries (Haciseferogullari et al., 2003). In addition, faba bean is one of the most efficient fixers of the atmospheric nitrogen and, hence, can contribute to sustain or enhance total soil nitrogen fertility through biological N_2-fixation (Lindemann and Glover, 2003).

In production, faba bean can be grown in rotation with cereal crops for improving soil physical condition, breaking disease cycles and controlling weeds (Duc, 1997). By cultivation area, it ranks fourth among the cool season food legumes (2.6 million ha year^{-1}), behind pea, chickpea and lentil (FAOSTAT, 2008). The world production in 2008 is about 26 million t for both green and dry bean (FAOSTAT, 2008). China is the leading faba bean producer with 43% of the world's faba bean crop, followed by Ethiopia, Egypt, France and Australia. However, in spite of its great potential for being an important protein source in many countries, its area of cultivation has been decreasing over the years (Torres et al., 2010). This acreage reduction is mainly attributed to the unstable yielding ability of faba bean.

Knowledge of the genetic diversity among conserved germplasm collections of a crop is essential and of critical importance in establishing, managing and ensuring a long-term success of crop improvement programs. Characterization of the genetic variation in the available germplasm is important for further improvement of crop yield and to impart

resistance to biotic and biotic stresses (Terzopoulos and Bebeli, 2008).

Though broad bean is not actually a crop of a high significance for Albanian agriculture, its use is constantly increased. Yet, the variation, distribution and the respective traits of local broad bean genotypes is poorly understood. Currently, there is an increased interest for the identification of best genotypes in terms of yield, protein content and biomass, and hence the main objective of this study was the investigation of morphological and phenotypic variations of several locally grown genotypes of faba bean (*Vicia faba* L.).

MATERIALS AND METHODS

The present study was conducted during the spring season of 2014 at the experimental facilities of Agricultural University of Tirana, Albania (41°21'35" N, 19°46'28" E). In the experiment were included 13 different locally grown broad bean genotypes (BG 144001 (1), BG 148005 (2), BG 146003 (3), BG 145002 (4), BG 793710 (5), BG 788700 (6), BG 789701 (7), BG 787699 (8), BG 790705 (9), BG 144001 (10), BG 147004 (11), AUT 0001 and AUT 0002) received from Albanian Genetic Bank, or collected during the collection expeditions of authors of this study, themselves.

The seeds were sown in pyramidal foam trays filled with peat and kept in a non-heated greenhouse. After the first true leaves were appeared the seedlings were transplanted half in the same greenhouse and the next half in open field nearby. 20 plants were transplanted for each genotype in a single line, either in greenhouse, or in open field. The planting distance was 60×15 cm. Crop management practices during the plant growth were similar to what is recommended for commercial production in that area.

Throughout plant growth, genotype characterization was conducted according to IBGRI descriptors. Several quantitative and qualitative traits have been described and analyzed including:

- Days to flowering
- Number of primary branches plant^{-1}
- Seed number pod^{-1}
- 100 seeds weight
- Number of pods node^{-1}
- Maximum number of seeds pod^{-1}
- Stem thickness (cm)
- Number of flowers inflorescence^{-1}
- Height of lowest pod-bearing node at harvest
- Number of pods node^{-1}
- Leaflet size
- Number of leaflets leaf^{-1}
- Wing petal color
- Pod angle/attitude at maturity
- Flower ground color

The genotypes with the best performance for specific traits were identified, as also for some of these traits the respective dendrograms were calculated as hierarchical cluster of a multivariate dataset based on dissimilarities (Wessa, 2014). This enabled real determination of relation and divergence level within faba bean germplasm collection. According to that, the similar genotypes, for a certain traits have been classified in the same groups. The respective dendrograms of only three traits are presented in this paper (height of lowest pod, number of days to flowering, and weight of 100 seeds).

RESULTS AND DISCUSSION

A broad phenotypic variation was found among characterized genotypes for several traits. So, for example, the number of primary branches plant^{-1} ranges from 1 to 7, the height of lowest pod bearing node from 6 to 41 cm, number of days to flowering from 54 to 72 days, the number of flowers for inflorescence from 4 to 13, the number of pods for node from 1 to 3, the weight of 100 seeds from 24 to 68 gr, and so on (Table 1).

Table 1. List of faba bean genotypes with the best performance for some evaluated traits.

Genetic parameter	Range	Accessions of best performance
Number of primary branches plant^{-1}	1-7	BG 144001, BG 148005, AUT 002, BG 793710
Stem thickness (cm)	4-8.5	BG 144001, BG 148005, BG 146003
Height of lowest pod-bearing node at harvest (cm)	6-41	BG 789701, BG 148005, BG 787699
Days to flowering	54-72	BG 144001, BG 148005, AUT 002, BG 147004
Number of flowers inflorescence^{-1}	4-13	BG 144001, BG 146003
Number of pods node^{-1}	1-3	BG 148005, BG 789701, AUT 001, BG 793710
Seed number pod^{-1}	3-5	BG 789701, BG 146003, BG 793710, BG 788700
100 seeds weight (g)	24-68	BG 793710, BG 148005, BG 789701, BG 787699

The largest number of branches plant^{-1} was expressed by BG 144001, BG 148005, AUT 002, BG 793710. The maximum was reached by BG 793710 (up to 7 branches plant^{-1}) while the rest of this group commonly produced up to 3 branches plant^{-1} (Table 1). Obviously this is an indication of plant vigor and plant biomass potentials, but as well, an indication of plant's seed production potentials. Of the lowest biomass potential were appeared BG790708, BG146003 and BG147004 (single stem). The largest number of genotypes appeared to be with small sized leaves (48%, Table 2). The rest was almost equally distributed between medium and large sized leaves. In a very high percentage (69%) the characterized genotypes had 4 leaflets leaf^{-1} (Table 2), which according to their shape were equally distributed between the elongate (46%) and sub elliptic (54%) mode.

Table 2. The frequency of distribution of several qualitative traits of faba bean genotypes.

Traits	Frequency (No.)	Percentage (%)
Leaflet size		
small	6	46
medium	4	31
large	3	23
Leaflet shape		
narrow (elongate)	6	46
intermediate (sub-elliptic)	7	54
rounded (sub-orbicular)	0	0
Number of leaflets leaf^{-1}		
3	1	8
3&4	3	23
4	9	69
Flower ground colour		
white	2	15
violet	1	8
mixed	10	77
Wing petal colour		
uniformly white	0	0
uniformly coloured	0	0
spotted	13	100
mixed	0	0
Pod angle/attitude at maturity		
erect	10	77
horizontal	1	8
pendent	0	
mixed	2	15

Table 2. Continued.

Traits	Frequency (No.)	Percentage (%)
Seed shape		
flattened	2	15
angular	0	0
round	0	0
mixed	11	85
Ground colour of testa (seed coat)		
light brown	7	54
light green	6	46
Hilum colour		
black	11	85
colourless	2	15

As earliness is a very important trait with high commercial importance for broad bean producers the identification of early genotypes is of a great interest. Apparently, the earliness of a certain broad bean genotype will depend on the number of nodes up to first pod bearing node, the flowering time and length of maturity period of settled pods. BG 789701, BG 148005 and BG 787699 were among genotypes with the smallest height of first pod bearing node. All three (numbers 2, 7 and 8) were grouped together in the respective dendrogram (Figure 1). Another group with a slightly higher number of nodes till the first fertile one was composed by BG 144001 (1), BG146003 (3), BG 145002 (4), BG 788700 (6), BG 789701 (7), BG 787699 (8), BG 144001 (10), BG 147004 (11). Two genotypes with extremely high number of nodes till the first bearing node were BG 793710 (5) and BG 790705 (9) which both composed a separate group far from the rest of genotypes (Figure 1). Anyway, the earliest flowering genotypes regarding the number of days to flowering were BG 144001(1), BG 148005 (2) and BG 146003 (3), all three grouped together in the respective dendrogram (Figure 2) and far from BG 145002 (4), BG 793710 (5) and BG 787699 (8), which are grouped together as the latest maturity genotypes.

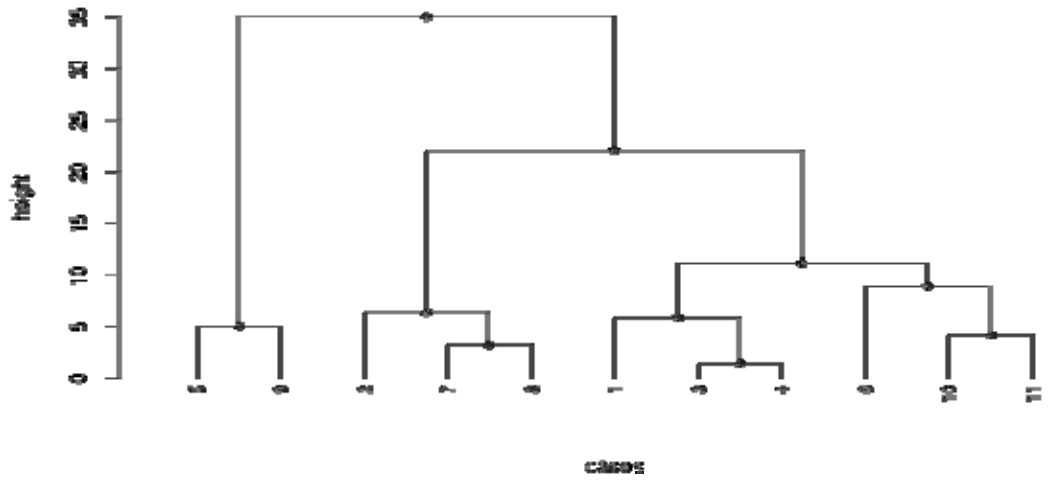

Figure 1. The dendrogram of 'height of lowest pod' trait of local faba bean genotypes.

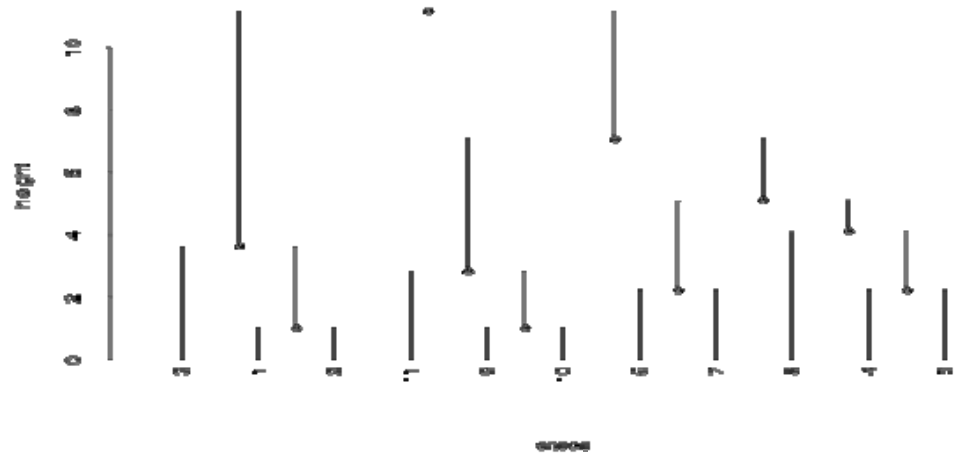

Figure 2. The dendrogram of 'number of days to flowering' trait of local faba bean genotypes.

The highest number of flowers inflorescence^{-1} was recorded for BG 144001 and BG 146003 (Table 1). In a very high percentage (77%, Table 2) the flowers were mixed according to ground color and 100% of them spotted by their wing color (Table 2).

A large majority of characterized genotypes (77%) were with erected pods at maturity (Table 2), and the largest number of pods node^{-1} at maturity (3) was recorded for BG 148005, BG 789701, AUT 001 and BG 793710. Meantime, according to number of seeds pod^{-1}, the best performance was expressed by BG 789701 (5 seeds pod^{-1}), followed by BG 146003, BG 793710 and BG 788700 with 4 seeds pod^{-1}. For the rest of genotypes only 3 seeds pod^{-1} were harvested.

In a very high frequency (85%) the seed shape of characterized genotypes was irregular. Only in 2 out of 13 genotypes (15%) the seeds were flattened (Table 2). The genotypes were almost equally distributed (54 versus 46%) according to color of seed coat between the light brown and light green, but in a very high frequency (85%) they were black colored regarding to hill color (Table 2).

As it is already stated above the variation regarding the seed weight was very large. According to that trait, BG 793710, BG 148005, BG 789701, BG 787699, were the genotypes with the best performance (Table 1). BG 793710 (5) has the highest 100-seed weight (68.54 g), and is quite distant from the rest of genotypes in the respective dendrogram (Figure 3). Meantime, BG 788700 (6) and BG 145002 (4) were with the lowest 100-seed weight (25.7 and 23.83 g, respectively), and also grouped together, separately from the rest of genotypes (Figure 3).

Figure 3. The dendrogram of 'weight of 100 seeds' trait of local faba bean genotypes.

CONCLUSSIONS

Significant phenotypic variation was found among locally grown Albanian faba bean genotypes. The highest variability was found regarding branching from basal nodes, height of lowest pod-bearing node, days to flowering, number of flowers inflorescence^{-1}, number of pods node^{-1}, number of seeds pod^{-1} and the weight of 100 seeds. The respective traits could be valuable for further breeding of best suited local commercial cultivars.

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