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Heritability and selection gain from autochthonic genotypic traits of birdsfoot trefoil (*Lotus conrniculatus* L.)

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Abstract

The goal of this study was to ascertain heritability and potential selection gain in 28 local genotypic traits of birdsfoot trefoil. Heritability and relative genetic gain from selection were calculated for yield and yield components of biomass and seed. Higher values of heritability for 1000 seed weight (98.26%) and height of plants (80.56%) indicated that their heritability was more influenced by genetic basis, then by the environment. Low degree of heritability was found for seed yield (11.04%) and number of husks (2.73%), which demonstrated that seed yield was under great influence of environmental factor. The obtained results of biometric analyses indicated that progress could be achieved in breeding of tested material. The results of these tests indicated the value of promising autochthonic genotypic traits, which can be used for further improvement of birdsfoot trefoil cultivars.

Keywords: Birdsfoot trefoil, Genotypic trait, Heritability, Selection gain, Variability

Introduction

Birdsfoot trefoil (*Lotus corniculatus* L.) belongs to the family of perrenial leguminosae plants (*Fabaceae*), and this is the most important group of plants for production of protein feed. It is particularly important in mixture of herbs and leguminosae plants for plantation of artificial lawns in mountain areas (Petrovic *et al*., 2011). Birdsfoot trefoil is widely spread throughout the world. It originates from Western Europe and Northern Africa (*Buselinck and Grant,* 1995). It is very valuable feed plant, and it takes an important place in seed structure (Vuckovic *et al*., 2005).

The inventory of land in Bosnia and Herzegovina was being developed over two vegetation seasons, and during that time seed of 28 birdsfoot trefoil offsprings were collected. Morphometric parameters were analysed on the spot where seeds were collected and data analysed and processed in laboratory demonstrated that these materials were of high propagation value. Applying the method of controlled propagation and planned selection of birdsfoot trefoil, it is possible to use heterosis of birdsfoot trefoil for generation of highly productive genotypic traits (Radic, 2014).

In order to achieve success in propagation, beside properly selected methods of propagation, it is also very important to collect selection material with higher genetic variability. Thanks to high variability and adaptability, as a response to selective conditions of the environment, natural selection enabled generation of a number of local ecotypes of red clover, which is cultivated and kept as a source of variability in some countries even nowadays (Lugic *et al*., 2007).

Heritability expresses a degree of compatibility of phenotypic values of specimens in certain population with their additive, *i.e*. propagation value (Falconer, 1981). Heritability is an important parameter in propagation of plants. Heritability has different values for certain properties. Properties of higher heritability are significantly influenced by genetic basis, but there are weaker or stronger influences of the environment to modification of that property. The size of phenotypic expression will, therefore, be determined mainly by the inheritance basis, to lesser extent by non-inheritance modifications (Miller and Hammond, 1991).

Garcia de los Santos *et al*. (2001) hybridised 27 local genotypic traits of *Lotus corniculatus* L. with two genetically different standards. The elements measured included ability of hybridisation, insemination, formation of husks, and living ability of *F1* generation, pollen sprouting, husk length and number of seed per husk. It was established that local genotypic traits of *Lotus* *corniculatus* L. can be used as quality germ plasma in classic selection methods.

Generation of new traits of *Lotus corniculatus* L. is a long-term and requiring process, since it includes studying of total germ plasm in the course of several selection cycles, and one selection cycle takes up to five years quite commonly. For successful selection it is important to know genetic variability and inheritance properties. Most of the agriculturally important properties (green mass yield, hay yield, plant height, etc.) have additive, i.e. collective effect of genes which influence the expression of properties, and this is why selection for these properties is complex and long-lasting (Gataric, 2005).

In cases when similarity between parents and offsprings is great, share of ecological variance is small, but genetic share is high. Thus the success in selection depends on estimation of share of certain components in total variability in form of heritability (Kraljevic *et al*., 1991). The selection problem of *Lotus corniculatus L*. is the high dormancy of the seed. The choice of genotype with better generative characteristics is very important for selection. A number of scientists have dealt with this problem.

Smith *et al.* (2009) and Beuselinck (2005) studied the influence of origins of seed from geographically and ecologically distant populations, taking into account their phenotypic and genotypic traits. They discovered regional differences in terms of plant size, sexual maturity, leaf size and fertility. Discrepancies in plant height, growth and leaf size from different habitats within regions and between ecotypes were obvious. Although it is important to take into account geographical position, selection of habitat is also an important characteristic, because phenotypic variations between ecotypes can be of specific importance for measured properties. Our agroecological conditions include large number of populations of *Lotus corniculatus* L. of great genetic variability (Radic, 2010). Variability for a number of agriculturally important properties is an important factor in the process of finding most productive ones, so it is also important for their introduction into further breeding process.

The goal of this study was to ascertain heritability and potential selection gain for 28 local genotypic traits of birdsfoot trefoil in order to get information about possibilities for the improvement of tested properties in selection of new, more productive cultivars.

Materials and Methods

Plant materials: Out of 28 collected offspring specimens from autochthonic populations, seed was planted in experimental fields in order to test their properties under the same ecological conditions (Fig 1). The study was conducted to the south from Banja Luka, in the site of Sljivno (N 44°40’57", E 16°59’38", elevation 513 *m*). Four plants from each offspring were tested in two rounds, in two vegetation seasons. Based on the obtained data, the analysis was developed for variances and each property was determined: summarised square, medium square, and error.

Fig 1. Experimental fields

Statistical analysis: Heritability coefficients were determined for relevant properties based on the relation of genotypic and phenotypic trait variances. The model was applied to disaggregate the entire variance into components, where values of *MS* (medium square) were taken as *MS* over two years of testing, *i.e*. as values of repletion in time (SPSS- Statistical Package for the Social Sciences).

Measured phenotypic values are not inherited entirely. A part of phenotypic variability, generated under the influence of external factors, pertains solely to the analysed generation. Only generic variability of analysed property is transferred to next generation. If genetic variability of a property is higher, there is greater possibility to transfer these properties to the progeny. The relation between genotypic and total phenotypic variances means heritability in wider sense.

Model for determining the heritability: According to the model disaggregation of phenotypic variation (Table 1), the following variances were separated:

$$\sigma_E^2 = MS_E$$
$$\sigma_R^2 = (MS_R - MS_E)/G$$
$$\sigma_G^2 = (MS_G - MS_E)/R$$

Total phenotypic variance was-

$$\sigma_F^2 = \sigma_G^2 + \sigma_E^2 / R$$

Heritability in wider sense was-

$$h^2 = (\sigma_G^2 / \sigma_F^2) \cdot 100\,(\%)$$

Based on the obtained coefficient values, it is possible to calculate potential genetic gain from the selection for each analysed parameter. According to Allard (1960), genetic gain from the selection depends on the following parameters:

$G = k \times S_F \times H$

Where *k* is value which includes selection differential which contains medium genotypic value between *q* selected strains and *n* initial strains from populations, phenotypic standard deviation and selection intensity, *i.e*. the percentage of plants selected for conceiving of next generation (*q/n*). Since "*k*" is expressed in standard deviation values, it is slightly changed and mainly depends on the selection intensity. At the selection intensity of 10%, value "*k*" is 1.76.

S_F is phenotypic standard deviation of medium values of the property to which selection is conducted of *n* initial strains.

H is coefficient of heritability obtained from the relation between genetic variance and total phenotypic variance.

Table 1. Model of disaggregation of phenotypic variation in single-factorial experiments

Source of variation	*Df*	$MS_{calculated}$	MS_{read}
Repetition (R)	*R* - 1	MS_R	$\sigma_E^2 + G \cdot \sigma_R^2$
Genotype (G)	*G* - 1	MS_G	$\sigma_E^2 + R \cdot \sigma_G^2$
Error (E)	(*R* - 1) × (*G* - 1)	MS_E	σ_E^2

Results and Discussion

The study found a strong and justified mutual influence of genotype and environment, so consequently their interactions influence properties of feed and seed yield in tested genotypes. The tests were conducted for the level of significance of P<0.01.

The coefficients of heritability: Based on the value of medium square of analysed properties of autochthonic populations of birdsfoot trefoil, heritability components and coefficients were determined (Table 2). It was esta--blished that lowest heritability is expressed for the property related to number of husks (2.73%) and seed yield (11.04%) per plant. The highest heritability coefficient was found for 1000 seed weight (98.26%) and plant height (80.56%).

Studying 45 genotypes of parent plants, Kelman (2006) found significant genetic variations between genotypes in semi-related traits and high variations in narrower terms of heritability (based on arithmetic mean for genotype), during blossoming phase (0.73 ± 0.11) for blossoming intensity (0.66 ± 0.12) and for plant height (0.78 ± 0.10). high assessed heritability for components of seed yield demonstrated that advantage in selection will be achieved in advance with planting in narrow and wide rows.

Heritability is a significant parameter for planned selection of birdsfoot trefoil. It is easier to do the selection according to properties with higher values of heritability, because their inheritance is under greater influence of genetic bases, and is less influenced by the environment. The obtained values of selected material demonstrated that greater heritability coefficient for the components of feed yield, while very low values were recorded for seed yield. Based on the obtained values, it could be concluded that greater effects can be achieved in the production of green mass than in the seed yield.

The selection genetic gain: Relative genetic gain from the selection is a relation between the obtained value of genetic gain and mean value of certain property, and is expressed in percentages. The applied statistical methods enabled the analysis of variability of tested quantitative properties, assessment of property inheritance and assessment of the selection genetic gain.

The populations tested through selection in the intensity of 10% were expected to demonstrate high genetic progress in feed production. With collected material it is possible to achieve production of green mass in relative terms by 38.60%. From the current average yield of green mass of 397 *g*, it is possible to achieve the improvement of genotype with green mass yield of 647.07 *g* if selection is applied. The yield of dry mass can be increased by the means of selection from average value of 139.71 to 215.17 g (Table 3).

Selecting 10% of highest plant phenotypes resulted in high estimated values of direct genetic gain (17.65 cm),

Table 2. Components of phenotypic variability and coefficients of heritability of tested parameters in population strain experiment

	Green mass	Dry matter	Height	Stem thickness	Number of stems	Number of husks	Seed yield	1000 seed weight
MS_R	181646.40	16184.60	178.6	0.08	3173.50	15171.84	121.66	0.01
MS_G	143621.02	15524.50	529.20	0.10	1466.90	28624.02	5.90	0.29
$MS_E = V_E$	17640.22	2507.20	30.10	0.02	265.30	27100.02	4.73	0.00
$V_R = (MS_R - MS_E)/G$	5857.36	488.48	5.30	0.00	103.86	426.01	4.18	0.00
$V_G = (MS_G - MS_E)/R$	31495.20	3254.33	124.78	0.02	300.40	762.00	0.59	0.14
$V_F = V_G + V_E$	49135.42	5761.5	154.9	0.04	565.70	27862.02	5.32	0.14
$h^2 = (V_G / V_F) \times 100$	**64.10**	**56.48**	**80.56**	**50.00**	**53.10**	**2.73**	**11.04**	**98.26**

*G = 28, R = 4

Table 3. Potential selection gain from autochthonic populations of birds foot trefoil

Property	Average population value	K	Phenotype variance	Phenotype standard deviation	h^2	Genetic gain (G)	Relative genetic gain (%)
Green mass (*g*)	397.00	1.76	49135.42	221.67	0.64	250.07	38.60
Dry matter (*g*)	139.71	1.76	5761.53	75.90	0.56	75.46	35.10
Height (*cm*)	49.46	1.76	154.88	12.44	0.81	17.65	26.30
Stem thickness (*mm*)	1.59	1.76	0.04	0.20	0.50	0.18	10.20
Number of stems	62.00	1.76	565.70	23.78	0.53	22.23	26.40
Number of husks	620.66	1.76	27862.02	166.92	0.03	8.03	1.30
Seed yield (*g*)	6.20	1.76	5.32	2.31	0.11	0.45	6.80
1000 seed weight (*g*)	1.08	1.76	0.14	0.38	0.98	0.66	37.90

which in relative terms presents increase of 26.30% compared to medium height plants. The number of stems per plant can be increased from 62 to 84 stems per plant if selection methods are applied.

Of all the analysed parameters, the lowest heritability was recorded for the number of husks per plant; thus it can be expected that this property will have the lowest gain of selection, i.e. only 8 husks per plant. Average seed yield of 6.20 *g* per plant can be increased by applying selection, and after the planned hybridisation to 6.65 *g* per plant. The greatest increase in analysed parameter can be achieved for 1000 seed weight, where considerably bigger seed grains can be obtained.

Conclusion

Heritability components and coefficients for eight morphological and productivity properties of birdsfoot trefoil were determined. Low heritability degree was determined for the seed yield (11.04%) and for components of seed yield (number of husks 2.73%), while heritability for the yield of green mass, number of stems and plant height ranged between 50 and 81%. Potential genetic gain from the selection for each of analysed parameters was calculated. The values of genetic gain enable us to select parents in order to obtain maximal recombining divergence and phenotypic-genetic expressivity of properties.

Selection of 10% of best plants of studied genotypes would enable us to get greatest genetic gain from the selection for the property of green mass yield. Selection of genotypes with best relation would ensure best progress in production and we would have a possibility to obtain considerably higher yields, which is the purpose of the production of birdsfoot trefoil. The expected results should be a guideline for the production practice. The results of this paper should be an incentive for research, valorisation and presentation of own scientific and natural resources. Use of own genetic resources not only for birdsfoot trefoil, but also for other plant species is very important for the protection and planned use of biodiversity.

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