Scientific Papers. Series A. Agronomy, Vol. LXIII, No. 1, 2020
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

ASSESSMENT OF THE ADAPTIVE CAPACITY OF SELECTION POPULATIONS OF BIRDS FOOT TREFOIL IN AGROECOLOGICAL CONDITIONS OF THE CENTRAL BALKAN MOUNTAIN

Boryana CHURKOVA

Institute of Mountain Stockbreeding and Agriculture Troyan, 281 Vasil Levski Street, 5600, Troyan, Bulgaria

Corresponding author email: bchurkova@abv.bg

Abstract

In the period 2016-2019, the following selection populations of birds foot trefoil were tested in the experimental field of Research Institute of Mountain Stockbreeding and Agriculture (RIMSA)-Troyan using the block method in four replications, with a size of the harvest plot of 5 m^2, compared to the Bulgarian variety 'Targovishte 1': Syn$_1$, Syn$_2$, Syn$_3$, Syn$_4$, Syn$_5$. It was found that for the specific environmental conditions of Troyan, the Syn$_3$ population achieved the highest productivity. Birds foot trefoil retained a high presence in the grassland during the second and third years of the experimental period in all tested populations, and the amount of stems predominated the leaves. Plant height (r = 0.7185) had the greatest influence on the formation of dry mass yield. A strong correlation dependence (r = 0.7891) was found between the height of plants and the amount of stems.

Key words: *Lotus corniculatus L., yield, morphological composition, height.*

INTRODUCTION

Birds foot trefoil (*Lotus corniculatus* L.) refers to legume forage plants with good adaptability to different soil and climatic conditions, high productivity and quality of forage. It is grown in pure crop or as a major legume component in mixtures (Vasileva, 2015; Vasileva and Ilieva, 2017) for combined use (Bozhanska, 2017; Bozhanska and Churkova, 2019) in Bulgaria. Soils with acid reaction are suitable for its growing (Churkova, 2013a). Different cultivars and populations of bird's foot trefoil originating in different regions are characterized by specific biological and morphological properties, such as growth and development, number and length of stems, productivity (Chourkova, 2010; Vasileva, 2017). The botanical composition of grassland provides information on the sustainability and stability of the yield of meadow grasses imported into Bulgaria. Specific adaptation and purposeful use may be the main determinants of species and crop selection (Parsons et al., 2011; Vasileva and Vasilev, 2012).

Studies on cultivars and populations of bird's-foot-trefoil, grown under the foothill conditions of Bulgaria, have been made, both with selection and practical orientation (Churkova, 2013b; 2013c; Bozhanska, 2018). The effect of adaptive variability of local populations and foreign cultivars on the yield of fresh and dry mass (Golubinova, 2018), persistence (Naydenova and Mitev, 2015), use, reproductive capacity and quality of feed (Churkova, 2011) has been registered.

Geographic location, biodiversity in structure and composition have an impact on the effective use of grasslands. The production of high quality feed organic production requires an optimal combination of environmental conditions and agrotechnical events (Allen et al., 2013; Semmartin et al., 2010) for the maximum development of grasslands. Appropriate adaptation of meadow grass species and cultivars is essential for realizing their genetic potential and hence their productive potential (DeBoer et al., 2017).

Recently, global environmental studies shown that the earth's climate is gradually warming. Modern agricultural science develops and implements innovative approaches to the selection of species and cultivars of fodder grasses for study in order to cultivate and use them in the changing environmental conditions (Golubinova and Marinov-Serafimov, 2019;

McDonagh et al., 2016; O'Donovan et al., 2016).

The aim of the present study is to evaluate the adaptive capacity of birds foot trefoil selection populations under the agroecological conditions of the Central Balkan Mountains.

MATERIALS AND METHODS

The experiment was cunducted in the period 2016-2019 in the experimental field of RIMSA-Troyan using the block method in four replications, with a size of the harvest plot of 5 m^2. The experimental variants were: Syn_1 (restricted free pollination of genotypes of 'Bright' and 'Georgia 1' cultivars), Syn_2 (pre-pollinated plants from the local population originating from the village of Staro selo and the Hungarian variety 'Ergechi'), Syn_3 (synthetic population from local genetic types originating in the Central Northern Bulgaria), Syn_4 (synthetic population from the Hungarian cultivars 'Pecoli' and 'Gjiki'), Syn_5 (synthetic population of genotypes originating from the towns of Shumen, Nessebar and Kiten) compared to the Bulgarian variety 'Targovishte 1' (control). The sowing was done manually, in a dispersed manner at a sowing rate of 12.0 kg ha^{-1}.

During the four years of the experimental period, two regrowths were harvested in hay harvesting stage in the phase of bud-formation period - beginning of flowering of birds foot trefoil.

The following indicators were registered: Dry vegetative matter yield (t ha^{-1}) - determined by drying average samples (200 g) in laboratory conditions until they reached constant weight at a temperature of 105ºC, hence it was calculated by regrowths, years and average over the experimental period based on green matter yield and dry matter content. The height (cm) of different mowings of the grassland was monitored at the time of harvesting. Plants (4 spots) were measured from the soil surface to the top of the tallest stems along both diagonals of each plot. The height of 40 birds foot trefoil plants was registered in each variant by years and regrowths. The average values were calculated from the data obtained. Morphological composition of the grassland (%) was determined by the weight percentage of 40 plants, taken from each variant and each replication during the grassland harvesting. The quantity of stems and leaves was determined by the weighting method and on its basis their percentage share was determined. The dry mass yields were processed by dispersion analysis method using the Analysis Toolpak software for Microsoft Excel 2010 and Statgraphics Plus v.2.1. The height and morphological composition of the grassland are represented by: limit values (min and max), average value (x), control deviation (SD) and coefficient of variation (CV, %). The degree of variability is considered to be very low, low, medium, high or very high with CV values, respectively: up to 7%; from 7.1 to 12%, from 12.1 to 20%, from 20.1 to 40% and over 40% (Lidanski, 1988).

RESULTS AND DISCUSSIONS

The meteorological characteristics of the vegetation period (March-October) during the survey years are quite different in terms of precipitation, which specifically affected the development and productivity of the grassland. The highest values are found in 2017 for the overall vegetation period and over the months and the lowest in 2019 (555.2 mm). The average temperature during the vegetation period had similar values over the years, respectively 15.2; 15.0; 15.3 and 15.6°C. The impact of climatic factors is a key indicator of the normal sprouting, growth, development and productivity of birds foot trefoil.

Dry mass yield (Table 1) in selection populations in the first year was relatively low compared to the control. Syn_2 population was distinguished with a slightly higher productivity than the control with a yield of 3.72 t ha^{-1} (+ 5.50% in comparison with the control). This is the only population with a yield above the control. Population Syn_5 had a similar value to control, and all other populations were significantly less productive. The lower productivity is determined by lower values of the main characteristics: plant height, leaf weight and stems.

Table 1. Dry mass yield (t ha^{-1}) over the years and average for the period 2016-2019

Populations	2016		2017		2018		2019		average for the period	
	t ha^{-1}	compared to control %	t ha^{-1}	compared to control %	t ha^{-1}	compared to control %	t ha^{-1}	compared to control %	t ha^{-1}	% compared to control %
Targovishte 1	3.53	100.00	5,65	100.00	13.07	100.00	8.16	100.00	7.60	100,00
Syn$_1$	3.21	91.00	5.48	97.00	13.13	100.44	7.78	95.33	7.40	97.34
Syn$_2$	3.72	105.50	5.56	98.39	12.89	98.63	9.55	117.07	7.93	104.33
Syn$_3$	3.42	96.95	6.34	112.34	13.35	102.13	10.01	122.68	8.28	108.93
Syn$_4$	2.88	81.79	6.06	107.23	12.90	98.70	10.29	126.07	6.46	84.98
Syn$_5$	3.49	98.95	5.93	104.96	1.57	111.44	8.60	105.34	8.15	107.15
LSD 5%	0.97	27.67	0.11	19.84	2.40	18.39	1.96	15.85	0.71	8.24
LSD 1%	1.35	38.32	1.54	27.48	3.33	25.47	2.72	21.96	0.98	11.41
LSD 0.1%	1.86	52.87	2.13	37.91	4.59	35.14	3.75	30.29	1.36	15.75

LSD – mathematical proof of diferences

In the second year of the experimental period, Syn$_1$ and Syn$_2$ populations had lower yields than the control. Population Syn$_3$ showed the highest productivity. It exceeded the standard by 12.34%. Yields exceeding the control were also reported in Syn$_4$ and Syn$_5$ populations. The high productivity in the second year of the experimental period was due to favourable climatic conditions. The combination of higher soil and air humidity with intense birds foot trefoil growth and development during this period explains the high productivity of its populations.

In the third year, Syn$_3$ and Syn$_5$ populations were more productive than the control. The highest value was found in Syn$_5$ population with a yield of 14.57 t ha^{-1} and an increase of 11.44%. The yield of dry mass of plants from populations that are more productive than the control is statistically unproven (Table 1).

In the fourth experimental year, dry mass yield varied from 4.23 to 8.77 t ha^{-1}. All populations exceeded the yield of the control, but Syn$_4$ population occupies the first position (10.29 t ha^{-1}) and exceeds the statistically significant control (26.07%). The excess was from 5.34% to 22.68% for the other populations. Syn$_1$ population is an exception and it is below the control. The high productivity in the fourth experimental year is due to the moisture, especially in April - 106.9 mm, June - 234.6 mm and July - 106.7 mm. That created excellent conditions for the growth and development of the plants and the formation of the two regrowths. The high yield prove the good persistence and survival of the plants until the end of the fourth vegetation in a great share of the studied populations, which are equal or have higher persistence than the control variety.

Over the study period, with the exception of Syn$_1$ and Syn$_4$ populations, all other populations were more productive than the control. Syn$_3$ population achieved the highest productivity. Syn$_5$ population ranks second in productivity with almost similar dry matter yield (8.15 t ha^{-1}), exceeding the control by 7.15%. The difference in the dry mass yield of the studied populations for each year of the experimental period can be explained by genetic differences, since the test was conducted under the same agro ecological conditions.

Table 2. Morphological analysis (%) by years and average for the period 2016-2019

Populations	2016		2017		2018		2019		average for the period	
	leaves	stems	leaves	stems	leaves	stems	leaves	stems	leaves	stems
Targovishte 1	50.0	50.0	50.0	50.0	50.0	50.0	41.7	58.3	47.9	52.1
Syn_1	60.0	40.0	45.5	54.5	54.5	45.5	41.4	58.6	50.3	49.6
Syn_2	50.0	50.0	46.7	53.3	53.8	46.2	41.7	58.3	48.1	51.9
Syn_3	55.6	44.4	43.8	56.2	54.5	45.5	40.0	60.0	48.5	51.5
Syn_4	57.1	42.9	37.5	62.5	53.8	46.2	36.1	63.9	46.1	53.9
Syn_5	44.4	55.6	50.0	50.0	53.3	46.7	42.9	57.1	4.6	52.4
X	52.8	47.1	45.6	54.4	53,3	46.7	40.6	59.4	48.1	51.9
SD	5.73	5.7	4.7	4.7	1,7	1.7	2.4	2.4	1.4	1.4
VC	10.8	12.2	10.2	8.6	3,2	3.6	5.9	4.0	2.8	2.6
Min	44.4	40.0	37.5	50.0	50,0	45.5	36.1	57.1	46.1	49.6
Max	60.0	55.6	50.0	62.5	54,5	50.0	42.9	63.9	50.3	53.9

The morphological composition of the grassland (Table 2) is an important indicator that affects especially the quality of the feed. The morphological composition of the grassland in the first year showed that Syn_4 population had the leaf mass of 57.1%. The average value of the stems was 47.1%, with a variation factor of 10.8%. The maximum value was registered for Syn_5 population - 55.6% and the minimum value for Syn_1 population - 40.0%.

In the second year, the number of stems exceeded the number leaves. The same percentage of leaves and stems was registered for the control and Syn_5 population. In the third year, the number of leaves was predominant and they ranged from 50.0% to 54.5%. Their degree of

variability was very low and almost similar both in terms of stems (VC - 3.6%) and in leaves (VC - 3.2%), according to the values of the variation coefficient.

The same trend as in the third year was observed in the fourth year, ie. The maximum values of the stalks were 63.9% and those the leaves 42.9%.

The number of stems in the majority of the population is average over the study period, with no significant variance found. This is also evident from the values of the variation coefficient for the stems and leaves, which are almost identical (2.8% and 2.6%). According to the results obtained for the percentage of leaves and stems, the populations do not differ from each other. The number of leaves varies within a very narrow range (46.1 to 50.3%). The same trend was observed in the percentage of stems (from 49.6 to 53.9%). On average for the experimental period, the lowest values were observed for the genotypes of Syn_4 population (46.1%) and the highest values for Syn_1 population (50.3%). Low values of control deviation indicate less scattering of the quantity of stems and leaves.

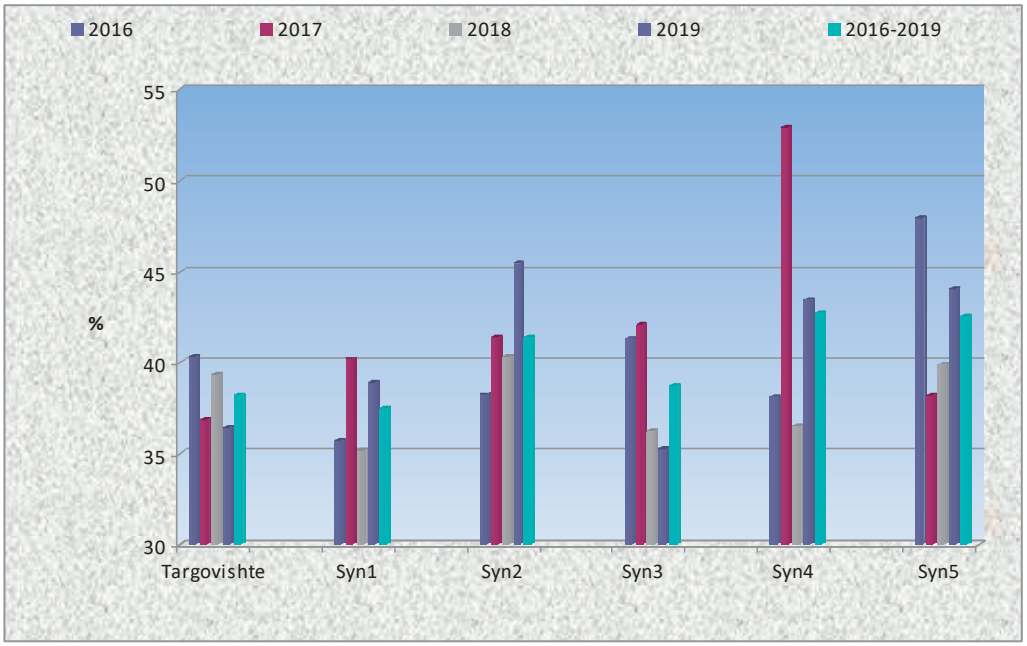

Figure 1. Height (cm) of stems of selection populations of birds foot trefoil over the years and average for the period 2016-2019

Table 3. Statistical processing of stem height (cm) of birds foot trefoil selection populations over the years and average for the period 2016-2019

Statistical values	2016	2017	2018	2019	Average for the period
X	40.24	41.91	37.87	40.55	40.14
SD	4.25	5.72	2.20	4.29	2.31
VC	10.56	13.66	5.80	10.57	5.76
Min	35.63	36.80	35.13	35.25	37.44
Max	47.93	52.88	40.28	45.40	42.72

The plants of Syn_5 population of the first regrowth in 2016 formed higher stems than 'Targovishte 1' (47.94 cm) (Figure 1). All tested populations except Syn3 remained below the control. Syn_2 (38.20 cm) and Syn_4 (38.10 cm) populations had similar values of stem height. Syn_4 population (52.88 cm) had the highest stems in the second experimental year. All populations had statistically proven higher stems than the control. There is a tendency of a parallel increase in the values of dry mass production with an increase in plant height.

In the third year of 2018, Syn_2 population (40.28 cm) had the highest values of stem height. The relatively similar height values of stems in the tested populations are noticeable.

The stem height in population Syn_2 (45.40 cm) exceeded 'Targovishte 1' in the first regrowth in 2019. The average stem height was 40.55 cm at a low degree of variability according to the value of the variation coefficient (CV-10. 57%).

The average stem height (Table 3) for the study period from all populations was 40.14 cm, with a very low degree of variability (CV - 5.76%), determined by the maximum (42.72 cm) and minimum values (37.44 cm). Variability of plant height in selection populations can also be used as an indicator of the adaptability of plants of selection populations to the agroecological conditions of the area. According to the values of variation coefficient

(CV), the degree of variability was low for the three experimental years and average for 2017. These values in the individual populations and the values of the coefficient of variation reflect the poorly manifested effect of environmental conditions on the height of the grassland.

Table 4. Correlation dependences among yield, percentage of stems, leaves and heights for birds foot trefoil populations (2016-2019)

Indicators	yield	leaves	stems	heights
Yield	**1**			
Leaves	-0.5210	**1**		
Stems	0.4582	-0.7484	**1**	
Height	0.7185	-0.7147	0.7891	**1**

Table 4 represents the linear correlation coefficients as plant height (r = 0.7185) is more influenced by the formation of dry mass yield. These results are consistent with Golubinova (2018), according to which the stem height has a greater impact on yield than their number regardless of the year of study (r = 0.703).The formation of dry mass yield in populations is mainly determined by the relative proportion of stems, which is confirmed by the positive relationship between these two indicators (r = 0.4582). A high level of correlation dependence (r = 0.7891) is characterized by the height to stem ratio.

Soil and climate conditions change the extent and nature of the relationship between productivity and quantitative characteristics of birds foot trefoil populations (Table 3). Debely et al. (2015) said that it is essential for plant selection to evaluate the individual elements determining yield, depending on environmental conditions. The same authors argue that the height of vetch determines productivity to the greatest extent, as this feature is characterized by high inheritance. These results are explained by the fact that the height of plants, as well as the percentage of leaves and stems in the grassland, are strongly influenced by the environmental conditions. In the presence of favourable soil and climatic conditions, the value of the correlation coefficient expressing the dependence of the characteristics with the productivity is positive and high.

CONCLUSIONS

Syn_3 had the highest dry mass productivity and yield stability from the tested populations. Its plants can be included as parental components to create a synthetic population.

Birds foot trefoil retained a high presence in the grassland during the second and third years of the experimental period in all populations, and the number of stems predominated the leaves.

Plant height (r = 0.7185) had the greatest influence on the formation of dry matter yield. A strong correlation (r = 0.7891) was found between the height of plants and the quantity of stems.

REFERENCES

Allen, E., Sheaffer, C., Martinson, K. (2013). Forage Nutritive Value and Preference of Cool-Season Grasses under Horse Grazing. *Agronomy Journal Abstract - Crop Economics, Production & Management, 105*(3)*,* 679–684.

Bozhanska T. (2017). Study on perennial legume-grass mixtures in the conditions of the Central Balkan mountain. *Banat's Journal of Biotechnology*, *VIII*(15), 34–42.

Bozhanska T. (2018). Botanical and morphological composition of artificial grassland of bird's–foot–trefoil (*Lotus corniculatus* L.) treated with Lumbrical and Lumbrex. *Banat's Journal of Biotechnology*, *IX*(19), 12–19.

Bozhanska, T., Churkova, B. (2019). Growth and of Legume and Grass Components in Mixed Grasslands Grown in the Central Balkan Mountain. *Trakia Journal of Sciences*, *1*, 19–27.

Churkova, B. (2010). Productive capacities, botanical composition and morphological characteristics of varieties and populations of birdsfoot trefoil. *Journal of Mountain Agriculture on the Balkans*, *5*(2), 829–838.

Churkova, B. (2011). Biochemical traits and correlation associations between chemical composition and some parameters yield in birdsfoot trefoil. *Banat's Journal of Biotechnology*, *II*(3), 25–28.

Churkova, B. (2013a). Agro-ecological aspects of the weed infestation control in birdsfoot trefoil grown for forage. *Banat's Journal of Biotechnology*, *IV*(7), 29–34.

Churkova, B. (2013b). Biological potential and adaptive capacity of varieties birds foot trefoil in the

agroecological conditions of Troyan. *Banat's Journal of Biotechnology*, *IV*(7), 69–73.

Churkova, B. (2013c). Content of crude protein, crude fiber and crude ash in dry mass of birdsfoot trefoil varieties and populations. *American Journal of Agricultural Science and Technology*, *1*(3), 77–83.

Debelyj, G. A., Kalinina, L. V., Mednov A. V., Goncharov, A. V. (2015). New generation of varieties of leguminous crops released by the Moscow Research Institute of Agriculture. *Scientific and production journal Grain-leguminous crops and cereals*, *1*(13), 1–14.

DeBoer, M. L., Sheaffer, C. C., Grev, A. M., Catalano, D. N., Wells, M. S., Hathaway, M. S., Martinson, K. L. (2017). Yield, Nutritive Value, and Preference of Annual Warm-Season Grasses Grazed by Horses. *Agronomy Journal Abstract - Crop Economics, Production & Management*, *109*(5), 2136–2148.

Golubinova, I. (2018). Comparative testing of varieties and local populations birdsfoot trefoil (*Lotus corniculatus* L.) *Journal of Mountain Agriculture on the Balkans*, *21*(6), 44–56.

Golubinova, I., Marinov-Serafimov, P. (2019). Influence of Meteorological Factors on the Productivity of Accessions Birdsfoot Trefoil (*Lotus corniculatus* L.). *Journal of Mountain Agriculture on the Balkans*, *22*(2), 82–93.

Lidanski, T. (1988). Statistical methods in biology and agriculture, Zemizdat, Sofia, BG.

McDonagh, J.,'Donovan, M. O, McEvoy, M., Gilliland, T. J. (2016). Genetic gain in perennial ryegrass (*Lolium perenne*) varieties 1973 to 2013. *Euphytica*, *212*(2), 187–199.

Naydenova, G., Mitev, D. (2015). Study of Breeding Populations of Birdsfood Trefoil and Red Clover in Mixtures. *Plant Science*, *LII*(5), 30–36.

O'Donovan, M., McHugh, N., McEvoy, M., Grogan, D., Shalloo, L. (2016). Combining seasonal yield, silage dry matter yield, quality and persistency in an economic index to assist perennial ryegrass variety selection. *Journal of Agricultural Science*, *155*, 556–568.

Parsons, A. J., Edward, G. R., Newton, P. C., Chapman, J D. F., Caradus, R., Rasmussen, S., Rowarth, J. S. (2011). Past lessons and future prospects: plant breeding for yield and persistence in cool-temperate pastures. *Grass and Forage Science*, *66*, 153–172.

Semmartin, M., Bella, C. D., Salamone, I. G. (2010). Grazing-induced changes in plant species composition affect plant and soil proper-ties of grassland mesocosms. *Plant and Soil*, *328*, 471–481.

Vasileva V., Vasilev, E. (2012). Study on Productivity of Some Legume Crops in Pure Cultivation and Mixtures. *Agriculturae Conspectus Scientificus*, *77*(2), 91–94.

Vasileva, V. (2015). Morphological parameters and ratios in some mixtures with subclover. *Science International*, *3*(4), 107–112.

Vasileva, V. (2017). Parameters Related to Nodulating Ability of Some Legumes. *International Journal of Agriculture Food Science & Technology*, *3*(1), 005–008.

Vasileva, V., Ilieva, A. (2017). Some physiological parameters in mixtures of cocksfoot and tall fescue with subterranean clover. *Bulgarian Journal of Agricultural Science*, *23*(1), 71–75.