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Research article

Seed yield and some of its structural elements in birdsfoot trefoil (*Lotus corniculatus* L.) cultivars

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Abstract

During the period 2011-2013 in the experimental field of RIMSA in Troyan the cultivars Bright, Georgia 1, Nueltin, Witt, Pardee, Roseau, Steadfast, Trevig of birdsfoot trefoil were investigated in comparison with the standard Targovishte cultivar. It was found that all studied cultivars in the fore-mountain conditions of Central Balkan Mountains showed better specific adaptive capacity, superior to the standard in average seed yield. The cultivars Georgia 1 (0.34 $t.ha^{-1}$) and Nueltin (0.32 $t.ha^{-1}$) were determined by ecological testing in pure and mixed stands to evaluate general adaptive capacity, as well as testing and multiplication in greater areas. The higher productivity of the studied birdsfoot trefoil cultivars compared with the standard was due to the formation of a larger number of pods per racemes, number of racemes per stems, number of seeds per pod and 1000 seed weight.

Key words: birdsfoot trefoil; cultivars; structural elements; seed yield

1. Introduction

The successful growing of perennial legume meadow grasses in the fore-mountain and mountain conditions is result of the resistance and survival of the cultivars. For these conditions, the priority is the production of forage

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with reduced costs of production, which determines the necessity of growing adapted cultivars to specific agro-ecological conditions. The problem of adaptation and establishment of cultivars with maximum stability of yield in the regional ecological conditions, for which they are intended, take a central place in contemporary breeding programmes (Dragavtsev, 1995). The ecological conditions of concrete region are determined by the interrelations between genotype and environment (Ayres at al., 2007; Pelikan, 2002). This requires the scientific research and plant breeding improving work to be orientated to selection of birdsfoot trefoil cultivars with high seed yield and good indicators of its structural elements. In number of publications has been indicated information about the nature of change in productivity depending on the location and meteorological conditions during the years of study (Kelman and Ayres, 2004; Vuckovic and Simic, 2005; Chourkova and Lingorski, 2011). The advantages of birdsfoot trefoil to be realized as an excellent legume forage grass, it is necessary a preliminary study of various foreign cultivars to specific environmental factors and growing conditions.

The aim of the investigation was to study the seed yield and its structural elements of foreign birdsfoot trefoil cultivars with a view to the possibility for direct introduction in production or their inclusion as genetic material in breeding programs.

2. Materials and methods

The research was carried out during the period 2011-2013 in the experimental field of RIMSA in Troyan on light grey pseudo podzolic soil. The trial was set out by the block method in 4 replications and harvest plot size of 5 m^2. The American cultivars of birdsfoot trefoil: Bright, Georgia 1, Nueltin, Witt, Pardee, Roseau, Steadfast and Trevig with origin USA were object of the research. The only Bulgarian cultivar Targovishte 1 was used as a standard. The sowing was performed manually, at a depth of 0.5-1.0 cm and sowing rate 12.0 $t.ha^{-1}$. The phosphorous and potassium fertilizers were applied as reserve at a rate of 240 $t.ha^{-1}$ a. i., while nitrogen was applied at a rate of 60 $kg.da^{-1}$, once before sowing. The birdsfoot trefoil was cultivated under the agricultural techniques, adopted in this area.

The first year was characterised with comparatively higher amount of precipitation in June (98.4 l/m^2), July (72.9 l/m^2) and August (96.8 l/m^2), when the seed cutting was formed. The higher air humidity delayed harvesting of seeds, which was performed in the final decade of August, but it did not obstruct to obtain high seed production of this sward.

The agro-meteorological characteristic of the second year of sward development was rather different than the other two years. The uneven distribution of precipitation in months was well pronounced, as humidity sufficiency was recorded in May (174.1 l/m^2) and there was lack of rainfall in July. That was a prerequisite for obtaining of lower seed yield from the second cutting.

Precipitation for the months of July and August in the third year was: 61.2 and 14.9 l/m^2, and the mean temperature was 19.4 and 14.9 $^{\circ}C$.

The seeds were harvested from the second cuttings when 65-70% of them became ripen.

The following indices were studied: **Structural elements of the seed yield** and **seed yield.**

2.1. Structural elements of the seed yield

The following indices were recorded: structural elements of the seed yield; number of racemes per stems; number of seeds per pod; number of pods per plant and stem height (cm). Samples were taken from 40 plants for

each variant and the obtained values were averaged. The study included average data of the different traits by years.

2.2. Seed yield

The seeds were harvested by hand from each plot and recalculated to t ha^{-1}.

2.3. Statistics analysis in birdsfoot trefoil cultivars

The average values (X), minimum (min) and maximum (max) limits of the structural elements and seed yield were calculated (Lidanski, 1988). The degree of variation (VC) of parameters was determined though variation coefficient according to the scheme of Mamaev: up to 7% – very low, from 7.1 to 12.0% – low, from 12.1 to 20.0% – moderate; from 20.1 to 40.0% – high: over 40.0% – very high. Correlations (r) of Brave and Pirson were calculated to prove the relations between the different parameters and their influence on productivity as well as between them. The data was processed by Microsoft Excel. The significant differences were determined by the methods of dispersion analysis.

3. Results and discussion

3.1. Structural elements of the seed yield

The influence of all factors contributing to the conducting of the experiment reflected on the productivity of the studied birdsfoot trefoil cultivars.

In the first year (Table 1) the data show that on the average for the whole studied period, the Bright cultivar had the largest number of pods per racemes – 5.2, number of racemes per stems – 4.9 and number of seeds per pod – 33.7 in comparison with the other investigated birdsfoot trefoil cultivars. From these parameters, the number of pods per racemes had the highest degree of variability which can be noticed from the value of variation coefficient (VC = 17.24). The values of stems height varied at close range in different cultivars respectively from 22.4 to 30.1 cm and VC = 9.19. The average value of height of the studied cultivars was 27.26 cm with standard deviation SD = 2.50 and variation coefficient VC = 9.19. The seed number per pod varied from 17.3 to 22.7 with variation coefficient 8.68 and standard deviation SD = 1.71. It is evident from the coefficient of variation that the degree of variation was low for this indicator. In the first year, the 1000-seed mass of all studied cultivars exceeded the level of the standard. It is evident that the degree of variation was medium for this trait. The cultivar Roseau showed the highest value of 1000-seed mass (1.8 g) followed by the cultivars Bright (1.7 g) and Nueltin (1.5 g).

In the next year (Table 2) the stems height of the studied cultivars varied from 29.4 to 36.6 cm, with average value X = 34.0 cm, low degree of variation and standard deviation SD = 2.2 and we can indicate that the cultivar Steadfast was the highest. The highest average value of number of pods per racemes of the cultivars was 3.7 and the degree of variation was the highest in comparison with other parameters. The second cut was formed during continuous drought. The cultivars Witt, Georgia 1 and Nueltin can be indicated as promising for this indicator.

Cultivar Witt was with the highest number of racemes per stems in this year and it formed 1.3 less number of racemes per stems. In the year 2012 the number of racemes per stems from the studied cultivars varied from 3.0

for cultivar Trevig to 4.9 for cultivar Witt. The variation coefficient of the cultivars of this indicator showed average value VC = 17.2.

The meteorological conditions in 2012 compared to those in the three years were with most unfavourable influence on the plant growth because of the severe drought during the months July and August and that in turn resulted in poor birdsfoot trefoil seed yield. This explains the earlier ripening of the seeds of birdsfoot trefoil and their earlier harvest than the usual one for this region. The seeds were smaller and the yields were lower.

The seed number per pod varied from 18.1 to 23.8 with mean values. It is evident from the coefficients of variation (VC = 8.38) that the degree of variation was low for this indicator. In this year the cultivar Trevig showed the highest value of 1000-seed weight (1.6 g). The lower coefficient of variation indicated that the cultivars showed their generative capacities depending on climatic conditions during the year of study as a result of their origin. The other cultivars had close values of this indicator as cultivar Targovishte 1.

In the third year (Table 3) of the study the mean height of studied cultivars was 44.7 cm with standard deviation SD = 2.6 and coefficients of variation VC = 5.8. The changes in the height of the cultivars during the three years were as a result of the rainfall in different time of the vegetation. The values of stem height of the studied cultivars in the years show that the investigation includes cultivars with appropriate height of the plants for mechanized harvest.

In the year 2013 of the experimental period, the cultivar Steadfast originating from USA had the greatest number of pods per racemes. This year had average degree of variability (VC = 14.8) in this parameter according to the value of the coefficient of variation. The structurial analysis of seed yield show correspondence between number of pods per racemes and number of racemes per stems. In this year number of racemes per stems was from 2.3 for cultivar Witt to 4.1 for cultivar Steadfast. This parameter was with the highest value of the variation coefficient (VC = 16.6) of all parameters characterizing the seed productivity. In total, it is observed a certain correspondence between the number of pods per racemes and number of racemes per stems during the years of study. In this year there was no cultivar that exceeded significantly the number of seeds in pod compared to the standard but with this trait the variation had less limit in comparison to the variation for the other indices (VC = 8.34). From the summarized data for the year it was observed that the cultivars had formed mean number of seeds per pod 19.69 with minimum value 17.20 and maximum value 21.80. The mean value for the 1000 seed weight was 1.6 g, with variation coefficient VC = 15.79 and standard deviation 0.23.

Number of pods per racemes and number of racemes per stems as parameters of the plants had the same dependences as in terms of the factor cultivar and in terms of the factor year. There were not significant differences in the influence of the year on these parameters, from which it can be concluded that the parameters of birdsfoot trefoil number of pods per racemes and number of racemes per stems are not significantly influenced by the weather conditions of the year. The cultivars Bright and Georgia 1 gave higher seed yield average for the three years and it was characterized by heavier seeds and number of seeds per pod in a birdsfoot trefoil. This shows that these two traits contributed to the formation of high seed yield of birdsfoot trefoil. The influence of the conditions of the year on these indices was proven particularly at the change of the number of seeds per pod in birdsfoot trefoil.

3.2. Seed yield.

The influence all factors contributing to the experiment reflected on the seed yield birdsfoot trefoil (Table 4). The yield from the crops in 2011 was significantly higher than the yield in 2012 and 2013, which can be explained by the much more favourable conditions for the development of birdsfoot trefoil throughout the entire vegetation period. In the first year the highest yield was obtained from the cultivar Nueltin – 0.36 $t.ha^{-1}$, followed by cultivars Bright – 0.34 $t.ha^{-1}$ and Georgia 1 – 0.33 $t.ha^{-1}$. Compared to the standard cultivar, the difference of the yields obtained from the weighed cultivars was respectively: 105.7%, 97.1% and 88.0%. The higher yield in these cultivars was due to the higher number of pods per racemes and number of seeds per pod. In all studied cultivars the positive difference of the seed yield was statistically well highly significant. The higher value of seed yield in all cultivars during the year was due to maximum plant growth and the formation of the largest number of generative stems with the highest value of structural elements of seed yield.

In the second year the obtained data show that the Georgia 1 cultivar demonstrated the best seed yielding capacity. The harvested seed yield was 0.38 $t.ha^{-1}$ and it was higher than the standard cultivar Targovishte 1. It was followed by Bright cultivar with 0.32 $t.ha^{-1}$ which exceeded the standard cultivar yield by 24.9%. Cultivar Roseau was ranked third regarding seed yield respectively with 20.0% higher than the standard. The increased yield of cultivar Georgia 1 was proved mathematically while the higher productivity of other cultivars compared with the standard was not mathematically proven. The differences in structural elements of the seed yield also caused different values of formed seed yield in the plants cultivars.

In the third year of the investigated period the seed yield of the studied cultivars of birdsfoot trefoil varied within a wide range: from 0.21 to 0.33 $t.ha^{-1}$. Greater seed yield compared to the standard Targovishte 1 was obtained from the following cultivars Bright, Georgia 1, Nueltin, Witt and Trevig. The cultivars Bright and Georgia 1 had very highly significant differences, while cultivars Nueltin, Witt and Trevig had highly significant differences.

Precipitation in July of 2013 (61.2 l/m2), combined with the normal average temperature for the month reflected favourably on the growth and development of birdsfoot trefoil, while lower values of temperature and rainfall in August (22.7 $^{\circ}C$ and 14.9 l/m^2) led to the normal maturity of seeds.

Average for the period of the study, all cultivars showed a significantly higher yield than the standard. The highest seed yield in cultivar Georgia 1 exceeded the standard by 60.4%. The cultivar Steadfast had the lowest productivity for the conditions of light gray pseudopodzolic soils and its yield exceeded the standard by 29.2%. The yields of all cultivars were with very highly significant differences compared to the standard.

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The obtained results show that the seed yield of birdsfoot trefoil cultivars depends on many factors. The cultivar as biological factor has a key role from the point of view of its main characteristics – adaptively and resistance

to biotic and aboitic stress. Due to the influence of extreme meteorological conditions on the adaptability and productivity of the birdsfoot trefoil, according Chourkova (2010) the factor should be determined before approving the new cultivar, so that it can show its potential during its distribution. The obtained different yields in the years indicated that the cultivars showed their productive capacities depending on climatic conditions during the years of study as a result of their origin.

4. Conclusions

The use of richer range of cultivars was a term for the obtaining of stable high yields in case of sharp deviations from the climatic norms. The structural elements of plants representing major components of yield are differentiated under the influence of factors cultivars and year.

All studied cultivars showed high seed productivity as over the years and the average for the period of investigation. Among the tested cultivars of birdsfoot trefoil the highest yield was obtained from cultivar Georgia 1 – 0.34 $t.ha^{-1}$, followed by cultivar Bright – 0.33 $t.ha^{-1}$and Nueltin – 0.32 $t.ha^{-1}$. These cultivars were with relatively stable seed productivity and in the three years of study.

The higher productivity of the studied birdsfoot trefoil cultivars compared to the standard was due to the formation of a larger number of pods per racemes, number of racemes per stems, number of seeds per pod and 1000 seed weight.

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Table 1. Structural elements of the seed yield for the year 2011

Cultivars	Stem height cm	Number of racemes per stems	Number of pods per racemes	Number of seeds per pod	1000 seeds weight
Targovishte 1	29.9	3.8	3.7	18.1	1.1
Bright	30.1	5.2	4.9	22.7	1.7
Georgia 1	28.1	4.7	4.3	21.6	1.3
Nueltin	28.3	4.1	3.7	20.3	1.5
Witt	22.4	4.3	3.6	18.4	1.2
Pardee	26.8	3.8	3.3	19.6	1.4
Roseau	24.9	3.6	3.1	17.3	1.8
Steadfast	26.0	3.7	3.0	19.2	1.5
Trevig.	28.8	3.7	3.1	20.1	1.5
X	27.3	4.1	3.6	19.7	1.4
Min	22.4	0.5	3.0	17.3	1.1
Max	30.1	5.2	4.9	22.7	1.8
VC	9.2	13.2	17.2	8.7	15.5
SD	2.5	0.5	0.6	1.7	0.2

Table 2. Structural elements of the seed yield for the year 2012

Cultivars	Stem height cm	Number of racemes per stems	Number of pods per racemes	Number of seeds per pod	1000 seeds weight
Targovishte 1	33.7	3.1	2.9	18.1	1.1
Bright	35.1	3.2	3.0	19.2	1.2
Georgia 1	34.9	4.7	4.1	23.8	1.3
Nueltin	35.8	4.5	4.0	20.1	1.5
Witt	35.4	4.9	4.2	19.7	1.3
Pardee	29.4	3.7	3.1	20.3	1.3
Roseau	32.2	3.5	3.2	20.1	1.2
Steadfast	36.6	3.1	3.0	21.2	1.0
Trevig.	33.2	3.0	2.7	20.7	1.6
X	34.0	3.7	3.4	20.4	1.3
Min	29.4	3.0	2.7	18.1	1.0
Max	36.6	4.9	4.2	23.8	1.6
VC	6.5	20.2	17.2	7.7	14.5
SD	2.2	0.8	0.6	1.6	0.2

Table 3. Structural elements of the seed yield for the year 2013

Cultivars	Stem height cm	Number of racemes per stems	Number of pods per racemes	Number of seeds per pod	1000 seeds weight
Targovishte 1	41.5	3.2	3.0	17.2	1.2
Bright	49.0	3.8	3.2	20.3	1.7
Georgia 1	45.7	3.0	3.0	21.8	1.3
Nueltin	43.8	3.1	2.8	20.3	1.2
Witt	42.8	2.7	2.3	19.8	1.8
Pardee	41.6	3.5	3.4	20.9	1.3
Roseau	44.3	3.9	3.2	21.1	1.5
Steadfast	47.3	4.2	4.1	18.3	1.7
Trevig.	46.2	4.0	3.8	17.5	1.6
X	44.7	3.4	3.2	19.7	1.5
Min	41.5	2.7	2.3	17.2	1.2
Max	49.0	4.2	4.1	21.8	1.8
VC	5.8	14.8	16.6	8.3	15.8
SD	2.6	0.5	0.5	1.6	0.2

Table 4. Seed yield over the years and mean for the period, t ha^{-1}

Cultivars	2011		2012		2013		Mean for the period	
	t ha^{-1}	% to St.	t ha^{-1}	% to St.	t ha^{-1}	% to St.	t ha^{-1}	% to St.
Targovishte 1	0.17	100.0-	0.25-	100.0	0.21	100.0-	0.21	100.0
Bright	0.34	197.1+++	0.32-	124.9	0.33	155.2+++	0.33	154.9+++
Georgia 1	0.33	188.0+++	0.38++	147.8	0.32	151.5+++	0.34	160.4+++
Nueltin	0.36	205.7+++	0.31-	119.5	0.29	138.0++	0.32	149.5+++
Witt	0.29	166.4+++	0.29-	113.1	0.29	135.9++	0.29	135.4+++
Pardee	0.29	170.1+++	0.29-	114.4	0.27	127.0+	0.28	134.0+++
Roseau	0.27	154.4+++	0.31-	120.0	0.26	121.9-	0.28	130.3+++
Steadfast	0.29	167.2+++	0.27-	105.2	0.26	125.6+	0.27	129.2+++
Trevig.	0.29	166.4+++	0.27-	106.4	0.29	138.7++	0.28	133.6+++
LSD 5%	0.02	14.6	0.07	30.04	0.05	24.1	0.03	14.4
LSD 1%	0.03	19.8	0.12	40.83	0.07	32.7	0.04	19.6
LSD 0.1%	0.04	26.6	0.14	54.69	0.09	43.8	0.05	26.2

+++, ++, + - = Significant at LSD ≤ 5%, LSD ≤ 1% and LSD ≤ 0.1%, respectively