Yield plasticity and stability assessment in orchardgrass varieties

Pavelas Tarakanovas

Lithuanian Institute of Agriculture, LT-5051 Dotnuva-Akademija, Kėdainiai, Lithuania

Field experiments with a view to assessing ecological plasticity and stability of orchardgrass varieties and lines were carried out at the Lithuanian Institute of Agriculture in Dotnuva on a loamy sod-gleyic soil in 1997–2000. It was determined that the factor of years of the experiment had the greatest effect on the variation of dry matter yield. Genotype–environment analysis showed that the variety 'Regenta' belonged to a group of varieties of intensive type. With regard to cultivation practices, it is a demanding variety and has the greatest potential of productivity. The variety 'Asta' has the greatest yield stability and can be recommended for cultivation in the conditions of extensive soil and crop management practices.

Key words: orchardgrass, dry matter yield, genotype–environment interaction

INTRODUCTION

Production of a stable and high dry matter yield under variable environmental conditions is a very important characteristic of a new orchardgrass variety [2]. The variety response rate is controlled by the genetic potential of a variety. The stability of the yield production depends on the ability of a variety to respond to environmental conditions. Varieties with a wide adaptability give stable, but lower yields in various environmental conditions, while varieties with a narrow adaptability give high yields in favourable conditions and low in unfavourable conditions [1]. In the cross-fertilization population of orchardgrass, the adaptability is based on a genetic homeostasis including not only heterogeneity, but also heterozygosity originating as a result of free pollination between the plants. All varieties of orchardgrass have a fairly wide range of response to environmental conditions. Nevertheless, varieties of orchardgrass differ significanly in their response to conditions of cultivation [2, 3]. Establishment of dry matter yield plasticity and stability parameters of a new variety enables to predict its response to changes in cultivation conditions and to recommend certain cultivation practices to produce optimum yields.

The aim of this study was to assess the parameters of plasticity and stability of dry matter yield of orchardgrass varieties and breeding lines.

MATERIALS AND METHODS

Two varieties ('Asta' and 'Regenta') and 3 breeding lines (Nos. 998, 1422 and 1164) of orchardgrass were used in our experiments to assess the ecological plasticity and stability parameters. The competitive variety trials of orchardgrass were carried out in Dotnuva in 1996, 1997 and 1998 on a light loam sod-gleyic soil with a 2–3% humus content and a pH value of 6.4–7.2.

Phosphoric and potassium fertilisers were applied in autumn at a rate of $P_{60}K_{90}$, and nitrogenous fertiliser N_{50} was applied early in spring and after each cut. Three cuts were taken annually. The first cut was taken at the stage of heading, the second cut in the third week of July, and the third at the end of September. The plot size was 10–12 m^2. Herbage samples of 0.5 kg were taken per each plot for determination of dry matter yield. The experimental data were processed by the genotype by environment analysis using the Selekcija software package [4].

RESULTS AND DISCUSSION

Analysis of variance showed that the factor of year and variety had a significant effect on the dry matter yield ($F_{act.}$ 105.94 > $F_{theor.\ 0.05}$ 2.29 and $F_{act.}$ 23.25 > > $F_{theor.\ 0.05}$ 1.57), and that there was a significant

action genotype–environment interaction ($F_{act.}$ 1.97 > $F_{theor.\ 0.05}$ 1.66), which enabled further analysis. The key parameter of analysis was considered the coefficient of linear regression b_i of productivity of varieties on gradation of ecological conditions, presented as average yield of all investigated varieties. The coefficient shows by how many units the productivity of a variety will vary at a modification of an index of conditions by a unit. The stability of yield was defined as its dispersion σ_d^2 in different conditions of cultivation. Thus, the plasticity of a variety should be perceived as its response to improvement in cultivation conditions and the stability as its feature to produce stable yields in different conditions.

In different experimental years the grass stands gave a diverse response to the changes in cultivation conditions. The indexes of environment show what yields were obtained in a specific year. The higher the index was, the better the investigated samples responded or adapted to cultivation conditions (Table 1).

The coefficient of linear regression b_i shows a response of a variety to changes in cultivation conditions. Its value can be higher or lower than 1, and also equal to 1. The higher the value of the regression coefficient ($b_i > 1$), the stronger a variety reacts to changes in cultivation conditions. Advanced cultivation practices are necessary to reveal the productivity potential of such varieties. If $b_i < 1$, a variety reacts more poorly to a change in cultivation conditions than on average the whole set of the test varieties. Such varieties are better utilised on extensive agrobackground, where they can give maximum outcome at minimum costs [6].

It is necessary to note that all the investigated varieties responded (b_i = 0.912–1.099) to changes in cultivation conditions. An especially good response to the improved cultivation conditions was demonstrated by the variety 'Regenta' (No. 1447). The variety 'Asta' was notable for the best yield stability (σ_d^2 = 0.144), No. 998 had the most stable yield (σ_d^2 = 0.703) (Table 2).

Table 2. **Results of integrated evaluation of orchardgrass varieties and lines**

Dotnuva, 1997–2000

Varieties and lines	Genotypic effect t/ha		Degree of plasticity		Sum of ranks	Stability σ_d^2
	E_i	Rank	b_i	Rank		
Asta	0.145	2	0.941	2	4	0.144
998	0.037	2	1.106	2	4	0.703
1422	–1.498	3	0.912	2	5	0.280
Regenta	1.095	1	1.099	2	3	0.258
1164	0.219	2	0.939	2	4	0.399
$LSD_{.05}$ = 0.324;			$PL_{.05}$ = 1 ± 0.229			

The productivity and plasticity of a variety are of importance in variety test trials. As the practical assessment of a variety cannot be based solely on the values of genetic effects or parameters of plasticity, a common (integrated) evaluation of a variety based on the sum of ranks E_i and b_i is adapted for these purposes [5]. According to the degree of productivity and plasticity all varieties are divided into three groups:

group I (rank 1) $LSD_{.05} < E_i$ and $1 - Pl_{.05} > b_i$;
group II (rank 2) $LSD_{.05} \le E_i \le LSD_{.05}$ and $1 - Pl_{.05} \le b_i \le 1 + Pl_{.05}$;
group III (rank 3) $LSD_{.05} > E_i$ and $1 + Pl_{.05} < b_i$,

where $LSD_{.05}$ and $Pl_{.05}$ are the least significant difference for genotypic effects and regression coefficient, respectively; E_i and b_i stand for the genotypic effect and regression coefficient, respectvely.

The relative practical value of the varieties is shown by the generalized integrated evaluation based on the sum of ranks of genotypic effects and the degree of plasticity of varieties. A less integrated evaluation specifies a great possibility of a variety to combine high productivity and plasticity in a specific cultivation region. In our experiments, the best-integrated (sum of ranks = 3) was given to the variety 'Regenta', which was distinguished by the greatest genotypic effect (E_i = = 1.095 t/ha, rank = by 1) and good plasticity (b_i = 1.099, rank = 2) on the dry matter yield (Table 2).

Table 1. **Variation of dry matter yield of orchardgrass varieties and lines in different environmental conditions**

Dotnuva, 1997–2000

Grass sowing / harvesting year	DM yield t/ha	Index of environment	Groups according to $LSD_{.05}$
1997/1999	11.88	–3.066	3
1998/1999	13.15	–1.791	3
1997/1998	14.74	–0.198	2
1998/2000	16.41	1.468	1
1996/1998	16.72	1.773	1
1996/1997	16.76	1.815	1
$LSD_{.05}$ = 0.362			

The worst parameters (sum of ranks = 5) were demonstrated by No. 1422, which had an essentially low genotypic effect (E_i = –1.498 t/ha, rank = 3) and an insignificantly lower than 1 regression coefficient (b_i = 0.912, rank = 2). Other lines had insignificantly low genotypic effects and received average parameters of an integrated evaluation (rank = 4).

We suggest that the variety 'Regenta' belongs to a group of varieties of intensive type and requires efficient crop and soil management to reveal its full potential of productivity. The variety 'Asta' producing the most stable yield can be cultivated on extensive agrobackground.

CONCLUSIONS

1. The analysis of variance showed that the year factor of the experiment had the greatest effect on the variation of dry matter yield. The genotype–environment interaction was significant, too.

2. The genotype–environment analysis showed that the variety 'Regenta' can be attributed to a group of varieties of intensive type. It requires advanced crop and soil management and has the greatest potential of productivity.

3. The variety 'Asta' demonstrated the greatest dry matter yield stability and can be recommended for cultivation in the conditions of extensive soil and crop management practices.

Received 18 May 2001

References

1. Bidinger F. R., Hammer G. L. and Muchow R. C. The physiological basis of genotype by environment interaction in crop adaptation. In: Plant Adaptation and Crop Improvement. CAB International. 1996, P. 329–348.
2. Christie B. R. and Armstrong K. C. Genotype × management interations among plants of orchardgrass (*Dactylis* gl. L.). Crop Science. 1968. Vol. 8, N 3. P. 285–288.
3. Gray E. Genotype × environment interactions and stability analysis for forage yield of orchardgrass clones. Crop Science. 1982. Vol. 22, N 1. P. 19–23.
4. Tarakanovas P. Statistinių duomenų apdorojimo programų paketas „Selekcija". Akademija, 1999. 57 p.
5. Джелали Н. И., Литун П. П. Методические указания по экологическому сортоиспытанию зерновых культур. Москва, 1980. 23 с.
6. Зыкин В. А., Мешков В. А., Сапегина В. А. Параметры экологической пластичности сельскохозяйственных растений, их расчет и анализ. Новосибирск, 1984. 24 с.

Pavelas Tarakanovas

ŠUNAŽOLIŲ VEISLIŲ DERLIAUS PLASTIŠKUMO IR STABILUMO ĮVERTINIMAS

S a n t r a u k a

Šunažolės lauko bandymai, tiriant sausų medžiagų derlių, plastiškumą ir stabilumą, buvo atlikti Lietuvos žemdirbystės institute, Dotnuvoje, velėniniame glėjiškame dirvožemyje 1997–2000 m.

Nustatyta, kad sausų medžiagų derliaus kitimui didžiausią įtaką turėjo bandymų atlikimo metai. Analizė genotipas–aplinka parodė, kad veislė 'Regenta' priklauso intensyviam veislių tipui, reikalaujančiam geros agrotechnikos ir turinčiam didžiausią derlingumo potencialą. Veislė 'Asta' turi stabilų derlingumą ir gali būti rekomenduota auginti ekstensyvios agrotechnikos sąlygomis.

Raktažodžiai: šunažolė, sausų medžiagų derlius, genotipas–aplinka analizė

Павел Тараканов

ПЛАСТИЧНОСТЬ И СТАБИЛЬНОСТЬ УРОЖАЯ У СОРТОВ ЕЖИ СБОРНОЙ

Р е з ю м е

Полевые опыты по изучению экологической пластичности и стабильности образцов ежи проведены в Литовском институте земледелия на дерново-глееватой оподзоленной легкосуглинистой почве в 1997–2000 гг. Установлено, что наибольшее влияние на изменение урожая сухого вещества оказывали годы проведения опытов. Анализ генотип–среда показал, что сорт 'Регента' относится к сортам интенсивного типа. Он требует хорошей агротехники и имеет наибольший потенциал урожайности. Сорт 'Аста' обладает наибольшей стабильностью урожая и может быть рекомендован для выращивания в условиях экстенсивной агротехники.

Ключевые слова: ежа, урожай сухого вещества, анализ генотип–среда