THE VARIABILITY STUDY OF SOME QUANTITATIVE TRAITS IN SUDAN GRASS [*SORGHUM SUDANENSE* PIPER. (STAPH.)]

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ABSTRACT

The research performed during 1996-1998 at A.R.S. Teleorman had as main objective the variability study of some quantitative traits to a Sudan grass germplasm consisting of 28 offsprings and two Romanian registered and extended cultivars, Sirius and Sonet. The aim of research was the identification of valuable genotypes and their extension into a breeding programme with a view to creating new Sudan grass cultivars. The variance analysis for the examined traits, pointed out that selection has successful chances for length, leaf breadth and grain weight, F factor was statistically assured at very significant level, for both leaf percentage and offshoot number per plant at distinctly significant level and for plant height at significant level. The established correlations between different investigated traits will be very useful to breeding works strategy at Sudan grass, the most important being: plant height x internode number, leaf length x foliar area, leaf breadth x foliar area, leaf length x leaf percentage, leaf breadth x leaf percentage.

Key words: Sudan grass, dry matter yield, fodder yield.

INTRODUCTION

One of the most important trait in Sudan grass, as fodder plant, is productivity.

Because of its good aftercutting growth ability, under dry land conditions, Sudan grass ensures two-three harvests during one vegetation period, with small yield differences between them, being an important component part of green conveyer.

The productivity of this specie is superior to the other annual fodder plants, even maize, because of roots dissolving emphasized abi-lity, strong reaction to fertilizers and irrigation, increased photosynthesis efficiency (Timirgaziu, 1971; Moga et al., 1996).

As well as to other crops, at Sudan grass too, the fodder yield represents, on the whole, the interaction between plants hereditary traits and vegetation conditions (Gumaniuc and Varga, 1988).

Unlike some authors as Bocsa (1981) who denies, actually, the possibility of increasing fodder yield by breeding, Varga et al. (1998), on the basis of forage plant breeding programmes from Romania and other countries, consider that it is genetically possible to increase the fodder yield, by improving the photosynthesis productivity as well as, indirectly, by diminution of losses produced by diseases, pests and stress factors. Facing such an important objective, as fodder yield, the breeder should directly and separately operate on the main elements which form the objective such as plant number/ha, offshoot number/plant, weight of an offshoot and number of cuttings/ vegetation period (Varga et al., 1987, 1988; Zamfir, 1999).

This paper presents a research complex regarding the variability of the main yield characteristics in Sudan grass in order to identify valuable genotypes from the existing biological material and their introduction into a breeding programme for releasing new cultivars.

MATERIALS AND METHODS

The research was performed at A.R.S. Teleorman, during 1996-1998, with a germplasm supplied by Forage Plant Technology and Breeding Laboratory of R.I.C.I.C. Fundulea and consisted of 28 offsprings and two Romanian cultivars registered and extended into production: Sirius and Sonet (Table 1).

The majority of progenies were extracted from the germplasm originating from U.S.A. (20) and the rest from Europe (Russia - 2, Romania - 2, Israel - 2, France - 1, Hungary - 1, Greece - 1).

During the three years of experimentation, the researches were performed at the level of individual plant as well as in dense cropping.

In order to determine the fodder yields, under dry land conditions a competitive trial was organized in randomized blocks and in three replications.

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The competitive trial was sown under conditions close as much as possible to the field ones (12.5 cm distance between rows, seed quantity which ensure 250 pl./m^2 etc.).

Table 1. Fodder yield (t/ha) achieved with Sudan grass progenies, harvested in prestalk shooting stage, 1996-1998 average

Variants	Years			Average		Signif.	Source
	1996	1997	1998	t/ha	%		
D28 (Privolzskaya)		19.30		16.41	129	***	Russia
Sonet		18.65		15.49	121	***	Romania
D27 (Voronenskaya 24)		17.69		15.42	121	***	Russia
D26 (Donskaya)		19.48		15.11	118	**	Russia
D7 (I.S. 3318)		18.45		14.85	116	**	USA
D13 (I.S. 3332)		17.99		14.25	112	*	USA
D25 (Krokion)		16.66		14.21	111	*	Greece
D24 (Szudan 2)		15.90		13.44	105	-	Hungary
D15 (I.S. 3341)		16.81		13.10	103	-	USA
D4 (I.S. 3313)		15.87		13.18	103	-	USA
D5 (I.S. 3314)		15.60		12.99	102	-	USA
D12 (I.S.3328)		17.04		13.02	102	-	USA
Sirius (control)		16.11		12.77	100	-	Romania
D10 (I.S. 3322)		16.01		12.63	99	-	USA
D6 (I.S. 3316)		15.67		12.70	99	-	USA
D19 (Piper)		16.55		12.66	99	-	USA
D21 (Advance)		14.67		12.48	98	-	France
D17 (I.S. 3351)		16.44		12.41	97	-	USA
D16 (I.S. 3342)		14.98		12.25	96	-	USA
D20 (PJ 226009)		14.06		11.97	94	-	USA
D2 (I.S. 3310)		15.21		11.97	94	-	USA
D18 (I.S.3353)		14.98		11.85	93	-	USA
D9 (I.S. 3321)		15.30		11.87	93	-	USA
D1 (3309)		14.63		11.58	91	-	USA
D11 (I.S. 3323)		15.79		11.24	88	o	USA
D22 (H-697)		16.22		11.09	87	o	Israel
D14 (I.S. 3336)		15.03		10.93	86	oo	USA
D23 (H-689)		14.53		10.83	85	oo	Israel
D8 (I.S. 3319)		14.46		9.99	78	ooo	USA
D3 (I.S. 3312) 8.27		13.08		9.20	72	ooo	USA
Average				12.45			
LSD 5%	1.37						

The data were statistically processed by the analysis of variance (Ceapoiu, 1968).

For the morphological traits of the examined cultivars and progenies, the correlation coefficients and regression equations of correlations were calculated.

From the viewpoint of rainfall during the vegetation period of Sudan grass (April-October) the three years of experimentation can be characterized as: 1996 – normal year, 1997 – rainy year, 1998 – droughty year (Figure 1).

RESULTS AND DISCUSSIONS

Dry matter yield

The Sudan grass harvesting was performed in prestalk shooting phenophase, at a plant height between 75–95 cm, obtaining three annual cuttings/year.

In 1996 (Table 1), the dry matter yield was comprised between 8.27 and 15.8 t/ha. The most productive progeny proved to be D28 (Privolzskaya), which exceeded the Sirius control with 4.05 t/ha, the yield gain being statistically ensured at very significant level.

The Sonet cultivar and D27 (Voronenskaya 24) progeny obtained yield gains statistically ensured at distinctly significant level and other four genotypes: D16 (I.S.3318), D24 (Szudan 2), D25 (Krokion), D26 (Donskaya) at significant level.

As a result of abundant pluviometric regime from 1997, on the whole, the fodder yield (dry matter), was very high. The maximum yield value (19.48 t dry matter/ha) was registered at D26 (Krokion) progeny, followed closely by D28 (Privolzskaya) progeny with 19.30 t dry matter/ha, when the achieved gains were at a distinctly significant level in comparison with control.

A good behaviour had also the following genotypes: Sonet (18.65 t dry matter /ha), D7 (I.S. 3318 with 18.42 t dry matter/ha), D13 (I.S. 3332 with 17.99 t dry matter/ha) and D27 (Voronenskaya 24 with 17.69 t dry matter/ha), with significant yield gains.

On an average, 16.11 t dry matter/ha have been achieved in 1997 experiment, in comparison with only 11.58 t dry matter/ha in 1996.

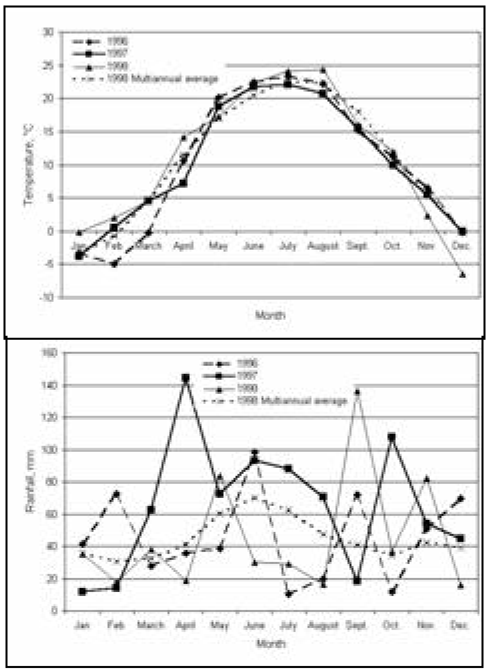

Figure 1. Evolution of mean temperatures and monthly rainfall in comparison with multiannual means of 100 years, during the experimentation period (Teleorman, 1996 – 1998)

In 1998, because of ununiform rainfall repartition during the vegetation period of Sudan grass, the dry matter yields were modest in comparison with those obtained in a favourable year (1997).

On the sum of cuttings, the progenies D28 (Privolzskaya) and D27 (Voronenskaya 24) have been noticed, which with 14.12 t dry matter/ha and 13.87 t dry matter/ha respectively, exceeded the Sirius control at a very significant level (gain 48% and 45% respectively). The genotypes Sonet and D7 (I.S.3318 with 35%), D13 (I.S. 3332) and D25 (Krokion with 33%) achieved distinctly significant yield gains and D26 (Donskaya with 30%), D4 (I.S. 3313 with 23%) and D25 (I.S. with 22%) achieved significant gains.

From the above mentioned data, results that, no matter how evolve the climatic factors, there are progenies which achieve superior yields in comparison with control Sirius, proving so a good stability. During the three years of experimentation, D28 (Privolzskaya) and D27 (Voronenskaya 24) exceeded the control at a very significant level, D26 (Donskaya) and D27 (I.S. 3318) at distinctly significant level, D13 (I.S. 3332) and D25 (Krokion) at significant level.

Weight of cuttings in fodder yield achievement

A special importance presents the weight of each cutting in fodder yield achievement. From table 2 it is evident that in Sudan grass harvesting in prestalk shooting, the weight of the three cuttings is more influenced by the climatic conditions of each year and less influenced by genotype. Thus, in droughty years (1996, 1998) the differences between cuttings are more substantial than in a normal or rainy year (1997), because the first cutting achieves the greatest yield, followed by greater and greater diffe-rences between next cuttings. In favourable years the first and second cuttings participate in fodder yield formation in a similar proportion.

Practically, it is preferable a well-balanced share of cuttings, so that, in the second part of summer, when in plain regions there is a fodder crisis, the second cutting cover this deficit.

On an average, during the whole experimentation cycle, at the 30 tested genotypes, the weight of the first cutting to the total fodder yield was 47.7%, the weight of the second cutting was 36.3% and the weight of the third cutting was 16.0% (Figure 2).

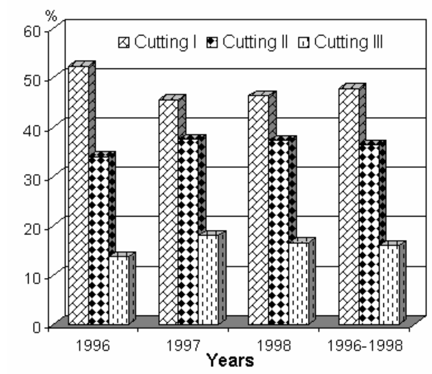

Figure 2. Graphic representation of cutting weight to the yield achievement at Sudan grass trial, harvested before stalk shooting stage

value and, generally, to the fodder quality improving.

In this sense, the yield of each cutting was analysed concerning the participation of different plant organs, in dry matter, to the yield formation. Data presented in table 3 show that the stem participation is greater in first cutting and decreases to the last, in favour of leaves.

From the analysed genotypes, a rich foliage was noticed to D8 (I.S. 3319), the leaves of which represent 41.1% in the first cutting, 46.7% in the second cutting and 61.3% in the third cutting.

Table 2 . Weight of cuttings in fodder yield achievement - prestalk shooting stage of cutting

Cultivars or variants	1996			1997			1998			1996-1998 mean		
	Cutting			Cutting			Cutting			Cutting		
	I	II	III	I	II	III	I	II	III	I	II	III
Sirius (control)	51.1	36.1	12.8	42.8	37.6	19.6	47.0	31.9	21.1	47.0	35.2	17.8
Sonet	49.5	37.0	13.5	43.7	37.6	18.7	45.4	36.6	18.0	42.6	37.1	16.7
D1 (I.S.3309)	57.2	29.2	13.6	40.3	38.3	21.4	45.5	35.3	19.2	47.7	34.3	18.0
D2 (I.S. 3310)	47.1	37.3	15.6	43.1	39.1	17.8	46.9	35.0	18.1	45.7	37.1	17.2
D3 (I.S.3312)	50.8	30.8	18.4	47.7	37.8	14.5	51.4	34.9	13.7	50.0	34.5	15.5
D4 (I.S. 3313)	53.5	34.1	12.4	42.8	37.6	19.6	45.7	36.2	18.1	47.3	36.0	16.7
D5 (I.S. 3314)	51.5	33.0	15.5	42.6	39.8	17.6	46.6	39.0	14.4	46.9	37.3	15.8
D6 (I.S. 3316)	53.7	31.7	14.6	43.3	36.7	20.0	48.0	35.0	17.0	48.3	34.5	17.2
D7 (I.S. 3318)	55.9	30.3	13.8	43.0	38.4	18.6	46.0	36.6	17.4	48.3	35.1	16.6
D8 (I.S. 3319)	51.8	36.0	12.2	49.9	37.3	12.8	34.2	42.3	23.5	45.3	38.5	16.2
D9 (I.S. 3321)	54.7	30.7	14.6	45.2	37.5	17.3	41.7	40.7	17.6	47.2	36.3	16.5
D10 (I.S. 3322)	49.2	34.6	16.2	41.9	39.0	19.1	47.5	38.1	14.4	46.2	37.2	16.6
D11 (I.S. 3323)	49.8	32.2	18.0	46.2	36.0	17.8	45.9	43.0	11.1	47.3	37.1	15.6
D12 (I.S. 3328)	52.0	36.0	12.0	42.3	39.6	18.1	47.4	35.0	17.6	47.2	36.9	15.9
D13 (I.S. 3332)	50.0	39.3	10.7	42.4	39.2	18.4	44.1	37.7	18.2	45.5	38.7	15.8
D14 (I.S.3336)	57.1	27.6	15.3	45.4	35.0	19.6	50.6	39.2	10.2	51.0	33.9	15.1
D15 (I.S. 3341)	51.1	32.3	16.6	43.0	38.6	18.4	47.7	38.2	14.1	47.3	36.4	16.1
D16 (I.S. 3342)	48.6	34.5	16.0	46.9	38.4	14.7	47.2	35.1	17.7	47.6	36.2	16.4
D17 (I.S. 3351)	48.9	36.4	14.7	41.7	39.6	18.7	49.2	30.7	20.1	46.6	35.6	17.8
D18 (I.S. 3353)	55.4	30.0	14.6	53.0	34.0	13.0	48.2	34.0	17.8	52.2	32.7	15.1
D19 (Piper)	54.1	34.9	11.0	47.0	34.2	18.8	44.9	39.0	16.1	48.7	36.0	15.3
D20 (PJ 226009)	52.6	37.1	10.3	40.0	37.7	14.3	45.5	41.2	13.3	48.7	38.7	12.6
D21 (Advance)	52.5	36.4	11.1	45.4	33.3	21.3	46.4	36.9	16.7	48.1	35.5	16.4
D22 (H-697)	54.9	29.3	15.8	45.6	38.3	16.1	48.2	39.0	12.8	49.6	35.5	14.9
D23 (H-689)	51.9	33.5	14.6	42.9	35.5	21.6	49.3	38.0	12.7	48.0	35.7	16.3
D24 (Szudan)	52.7	34.8	12.5	41.4	39.4	19.2	47.6	40.2	12.2	47.2	38.1	14.7
D25 (Donskaya)	52.9	36.0	11.1	44.3	40.0	14.9	48.1	33.0	18.1	48.4	36.9	14.7
D26 (Krokion)	50.8	37.4	11.0	44.6	37.5	17.9	45.5	38.2	16.3	47.0	37.7	15.3
D27 (Voronenskaya)	54.9	34.7	10.4	44.3	35.0	20.7	43.3	37.1	19.6	47.5	35.6	16.9
D28 (Privolzskaya)	52.6	37.3	10.1	43.1	40.3	16.0	44.1	39.2	16.7	46.6	38.8	14.5
Average	52.3	34.0	13.7	45.5	37.5	18.0	46.3	37.2	16.5	47.7	36.3	16.0

Weight of plant component parts to the fodder yield achievement

The increase of the weight of valuable component parts (leaves) in total dry matter yield /surface unit, contributes to the sensitive improvement of consumability, of energetical

On the average of studied genotypes during the three years of experimentation, the first cutting consisted of 33.0% leaves, the second cutting - 39.6% and the third cutting - 43.6% (Figure 3).

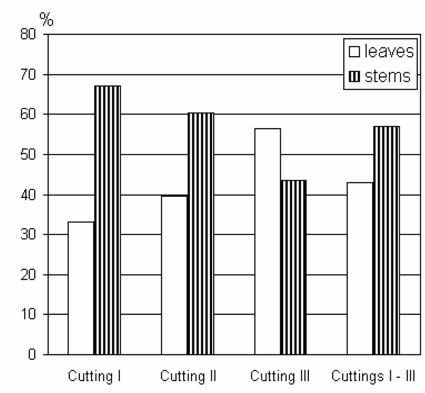

Figure 3. Graphic representation of plant component weight, in Sudan grass fodder mass, harvested before stalk shooting stage

in dense crop, a very significant positive correlation was established (Figure 4); this finding is very useful for breeding activity, because it is known that selection takes place on indivi-dual plants and its effects are not always found again in dense crop.

Table 4 presents a synthesis of results concerning the leaf area and leaf area index. As regards the leaf area, Sirius cultivar uti-lized as control, was exceeded by 18 genotypes at very significant level and by 3 genotypes at significant level.

On an average, during three years and on three cuttings, the leaf area index values vary between 1.63 and 3.04.

Table 3. Weight of component parts of Sudan grass in fodder yield achievement, prestalk shooting harvesting, 1996-1998 average

Variants	First cutting		Second cutting		Third cutting	
	Leaves	Stems	Leaves	Stems	Leaves	Stems
Sirius (control)	30.5	69.5	36.7	63.3	52.2	47.8
Sonet	32.8	67.2	38.4	61.6	55.1	44.9
D1 (I.S. 3309)	28.4	71.6	35.3	64.7	53.6	46.4
D2 (I.S. 3310)	32.0	68.0	36.1	63.9	58.1	41.9
D3 (I.S. 3312)	32.2	67.8	36.9	63.1	57.0	43.0
D4 (I.S. 3313)	29.7	70.3	35.4	64.6	52.8	47.2
D5 (I.S. 3314)	34.1	65.9	42.6	57.4	57.6	42.4
D6 (I.S. 3316)	34.5	65.5	42.9	57.1	56.3	43.7
D7 (I.S. 3318)	35.8	64.2	43.4	56.6	58.2	41.8
D8 (I.S. 3319)	41.0	59.0	46.7	53.3	61.3	38.7
D9 (I.S. 3321)	32.6	67.4	37.3	52.7	57.4	42.6
D10 (I.S. 3322)	32.2	67.8	38.1	61.9	58.1	41.9
D11 (I.S. 3323)	33.0	67.0	38.5	61.5	60.2	39.8
D12 (I.S. 3328)	39.3	60.7	46.2	53.8	59.5	40.5
D13 (I.S. 3332)	33.8	66.2	39.1	60.9	57.3	42.7
D14 (I.S. 3336)	33.4	66.6	39.6	60.4	58.5	41.5
D15 (I.S. 3341)	35.3	64.7	43.8	56.2	58.2	41.8
D16 (I.S. 3342)	37.7	62.3	45.6	54.4	60.4	39.6
D17 (I.S. 3351)	32.5	67.5	38.5	61.5	56.5	48.5
D18 (I.S. 3353)	36.8	63.2	44.7	53.3	58.7	41.3
D19 (Piper)	28.2	71.8	35.4	64.6	54.9	45.1
D20 (PJ 226009)	30.1	69.9	37.7	62.3	55.8	44.2
D21 (Advance)	31.7	68.3	37.9	62.1	56.1	43.9
D22 (H-697)	37.4	62.6	45.2	54.8	59.0	41.0
D23 (H-689)	28.9	71.1	36.0	64.0	52.7	47.3
D24 (Szudan 2)	33.2	66.8	39.4	60.6	53.8	46.2
D25 (Donskaya)	30.1	69.9	38.5	61.5	54.0	46.0
D26 (Krokion)	33.0	67.0	39.3	60.7	57.0	43.0
D27 (Voronenskaya 4)	29.8	70.2	36.1	63.9	49.9	50.1
D28 (Privolzskaya)	29.9	70.1	35.4	64.6	51.2	48.8
Mean	33.0	67.0	39.6	60.4	56.4	43.6

Leaf area and leaf area index

Unlike leaf area values registered to the individual plants, in dense crop, because of competition between plants, the offshoots present smaller dimensions of foliage and consequently, less values of leaf area/plant.

Between leaf breadth determined at individual plant level and leaf breadth determined

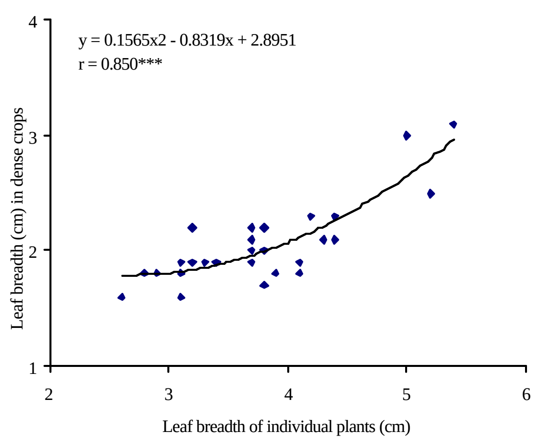

Figure 4. Relationship between leaf breadth at individual plants and in dense crop, in Sudan grass offsprings

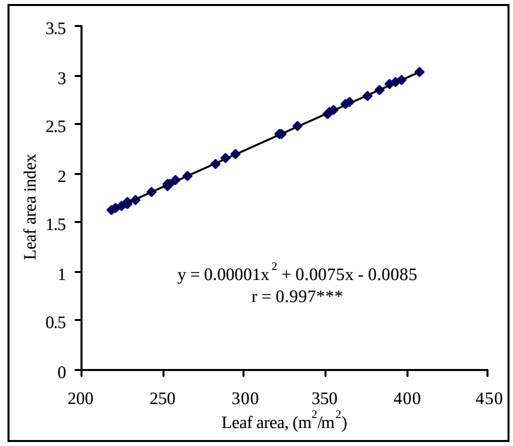

Figure 5. Relationship between leaf area and leaf area index in Sudan grass competitive trials, harvested before stalk shooting stage, 1996-1998 average

Table 4. Synthesis of results regarding the leaf area and leaf area index in Sudan grass competitive trials, harvested in prestalk shooting stage, 1996-1998 average

Variants	Leaf area (m^2/m^2)	Diff. m^2/m^2	Signif.	Mean L.A.I.	Regeneration rhythm (1-9)
D8 (I.S.3318)	407.63	+188.81	***	3.04	4
D12 (I.S.3328)	396.78	+177.96	***	2.96	2
D7 (I.S.3318)	393.62	+174.80	***	2.94	3
D18 (I.S.3353)	389.92	+171.10	***	2.91	3
D11 (I.S.3323)	383.06	+164.26	***	2.86	2
D13 (I.S.3332)	375.68	+156.86	***	2.80	2
D5 (I.S.3314)	365.22	+146.40	***	2.73	4
D16 (I.S.3342)	362.27	+143.45	***	2.71	2
D26 (Donskaya)	354.56	+135.74	***	2.65	1
D14 (I.S.3336)	352.65	+133.83	***	2.63	3
D22 (H-697)	351.14	+132.32	***	2.62	4
D9 (I.S.3321)	333.01	+114.19	***	2.49	2
D15 (I.S.3341)	323.41	+104.59	***	2.41	2
D24 (Szudan2)	321.97	+103.15	***	2.41	3
D21 (Advance)	321.74	+102.92	***	2.40	5
D28 (Privolzskaya 24	294.66	+75.84	***	2.20	1
D27 (Voronenskaya 24)	288.89	+70.07	***	2.16	2
D10 (I.S.3322)	282.98	+64.10	***	2.11	2
D25 (Krokion)	265.43	+46.61	***	1.98	2
Sonet	258.08	+39.26	*	1.93	2
D3 (I.S.3312)	254.77	+35.95	*	1.90	4
D6 (I.S.3316)	252.89	+34.07	*	1.87	3
D1 (I.S.3309)	252.46	+33.64	-	1.88	3
D4 (I.S.3313)	243.67	+24.85	-	1.83	3
D20 (PJ226009)	232.79	+13.97	-	1.74	1
D17 (I.S.3351)	228.92	+10.10	-	1.71	2
D19 (Piper)	227.79	+8.97	-	1.70	5
D23 (H-689)	224.20	+5.38	-	1.68	4
D2 (I.S.3310)	220.72	+1.90	-	1.65	3

Between leaf area and L.A.I. there is a strong relationship, proved by the very significant correlation presented in figure 5.

As regards the regeneration ability after cutting (Table 4), the genotypes Sirius, D20 (PJ 226009), D26 (Donskaya) and D28 (Privolzskaya) presented the most rapid rege-neration rhythm (note 1).

CONCLUSIONS

The germplasm tested presents a large variability of traits which contributes to the achievement of superior yields in comparison with cultivars extended into production.

The offsprings D28 (Privolzskaya), D27 (Voronenskaya 24), D26 (Donskaya) and D27 (I.S.3318) achieved, on an average during the three years, 14.9-16.4 t dry matter/ha, exceeding the Sirius control with yield gains statistically ensured.

The genotypes D28 (Privolzskaya), D24 (Szudan 2) and D13 (I.S. 3332) have been selected for a better repartition of yield per cuttings (45.5 - 48.8% – first cutting; 38.7 - 38.9% – second cutting), the third harvest being with 3.5 - 3.7% bigger than control (35.2%).

The offspring D8 (I.S. 3319) was chosen for its rich foliage, with a leave percentage of 41.0% in first cutting, 46.7% in second cutting and 61.3% in third harvest.

From the germplasm tested, 14 offsprings which achieved superior or at least equal yields in comparison with Sirius control, have been selected. For their utilization in new synthetic cultivar develoment, it is necessary:

- their self-fecundation, because of very large variation amplitude of some traits;

- determination of general combining ability by polycross test.

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Table 1. Influence of aluminum ions, in reaction mixture, on the level of saccharasic activity in a reddish-brown soil fertilized with compost with different quantities (glucose+fructose-mg/100 g soil dw/24 hours)

A- Factor	B – Factor – COMPOST (t/ha)								Average (A)	
	b1-0	%	b2-0	%	b3-0	%	b4-0	%		%
a1–without Al^{3+}	b 3287	100	b 4028	100	b 2579	100	b 3472	100	b 3341	100
a2- with Al^{3+}	a 4228	129	a 5019	125	a 3472	135	a 4528	130	a 4312	129
Average (B)	3757 c		4523 a		3025 d		4000 b			

LD P	5%	1%	0,1%
A	291	673*	2143
B	101	142	201*
AB	302	628*	1799
BA	144*	201	284

Table 2. Influence of aluminum ions, in reaction mixture, on the level of saccharasic activity in a chernozem mineral fertilized or manured with farmyard compost (glucose+fructose-mg/100 g soil dw/24 hours)

A- Factor	B – Factor – COMPOST (t/ha)										Average (A)	
	b1-0	%	b2-$N_{32}P_{32}$	%	b3-$N_{94}P_{96}$	%	b4-$N_{128}P_{128}$	%	b5 compost	%		%
a1–without Al^{3+}	b 1564	100	b 1496	100	b 1459	100	b 1401	100	b 1732	100	b 1530	100
a2- with Al^{3+}	a 1686	108	a 1581	106	a 1684	115	a 1589	113	a 1864	108	a 1681	110
Average (B)	1625 b		1538 d		1571 c		1495 e		1798 a			

LD P	5%	1%	0,1%
A	7	17	54*
B	14	20	27*
AB	19	28	45*
BA	20*	28	39