Biblid: 1821-4487 (2019) 23; 2; p 88-95
UDK: 581.48

Original Scientific Paper
Originalni naučni rad

STABILITY OF GRAIN NUMBER PER PANICLE IN A COLLECTION OF AUTUMN OAT (*AVENA SATIVA* L.) GENOTYPES

STABILNOST BROJA ZRNA PO KLASU U KOLEKCIJI OZIMIH GENOTIPOVA OVSA (*AVENA SATIVA* L.)

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ABSTRACT

The purpose of this study is to examine the stability of grain number per panicle in a collection of autumn oat genotypes under different climatic conditions. The biological material analysed consisted of 73 oat genotypes studied over a period of three years. The experimental data were obtained by biometric measurements and subsequently processed using the following linear regression models: Finlay-Wilkinson, Hardwick-Wood, Muir and Wrike. The grain number per panicle obtained varied according to the annual climatic conditions both as means and the intrapopulational variability. The Jefferson, Carrie and Florina cultivars, as well as the 4458, PA 725-4743 and PA 822-818 lines, exhibited a high dynamic stability associated with the above-average values of the grain number per panicle. Relative to this character, a total 53.10 % of the genotype x environment interaction is due to the heterogeneity of variances.

***Key words**: oats, stability, grain number per panicle.*

REZIME

Svrha ove studije je da se ispita stabilnost broja zrna po klasu u kolekciji ozimih genotipova ovsa u različitim klimatskim uslovima. Analizirani biološki materijal sastojao se od 73 genotipa ovsa, ispitivanih tokom perioda od tri godine . Eksperimentalni podaci su dobijeni biometrijskim merenjima i naknadno obrađeni korišćenjem sle dećih modela linearne regresije : Finlai-Vilkinson, Hardvick-Vood, Muir i Vrike. Broj zrna po dobijenim klasu varirao je u zavisnosti od godišnjih klimatskih uslova i po srednjoj vrednosti i kao intrapopulacijska varijabilnost. Sorte Jefferson, Carrie i Florina, kao i linije 4458, PA 725-4743 i PA 822-818, pokazale su visoku dinamičku stabilnost povezanu sa iznad-prosečnim vrednostima broja zrna po klasu. U odnosu na ovaj pokazatelj, ukupno 53,10% interakcije između genotipa x i okoline je rezultat heterogenosti varijanse.

***Ključne reči:** ovas, stabilnost, broj zrna po klasu.*

INTRODUCTION

The interaction between the oat genotype and the environment exerts significant effects on the grain production and quality. Under different environmental conditions, oat genotypes vary relative to the production of grains, the mass of 1000 grains, the percentage of chaff, the starch content and the β-glucan content. Oat genotypes with high quality and production values, as well as a high stability of characters, have the ability to pass these attributes to their progeny (*Mut Zeki et al. 2018*). The production performance of autumn oat genotypes can be evaluated according to precocity, winter resistance, plant height, panicle length, spike number per panicle, grain number and weight per panicle and the mass of 1000 grains. These plant characters are of vital importance to the selection of genotypes in both breeding and hybridization programs (*Panayotova Galina et al., 2018*). The diversification of production characters has also been attempted through the use of biotechnology in breeding programs. The value of regenerated plants obtained from mature embryos is assessed relative to the height of plants, the length of panicles, the number of spikes per panicle, the number of grains per panicle, the weight of grains per panicle and the weight of 1000 grains. In addition to the morphological features of productivity, it is also necessary to evaluate the quality properties such as the protein and fat contents. Regenerated plants may be higher, featuring longer panicles and larger grain number per panicle (*Dyulgerova Boryana and Savova Todorka, 2017*). Of the climate factors exerting a major influence on the panicle productivity, drought is the most important. Due to genetic variability, some oat genotypes tolerate drought better than others. The data on valuable oat genotypes can be collated by different genetic variability assessments and measurements of the stress factor effect on the specific morphological character of the plant. One of the characters recommended for evaluation is the grain number per panicle, alongside the grain mass per panicle, i.e. the mass of 1000 grains. The stress factor sensitivity index and the tolerance index (*Atefah Zaheri and Sohbat Bahraminejad, 2012*) are the stability indicators which should be determined. The stability of panicle productivity can also be examined by comparing some hybrid populations with parental forms. Assessments of generational behaviour over a period of several years have been performed by studying the number of panicles per plant, the number of grains per panicle and the weight of grains per panicle. The combinatorial ability of progenitors has been found to be of paramount importance to the manifestation of certain characters and their response to environmental factors *(Igor Pirez Valério et al., 2009*). Relative to the character stability in autumn oats, correlations between specific characters can facilitate their determination and better comprehension. A number of studies conducted in Turkey used linear stability regressions and determinants as stability indices for oat character description. The characters examined were affected differently by the interaction between oat genotypes and the environment. The coefficients of correlation obtained for the characters studied differed according to environmental conditions. Furthermore, a correlation was found between the productivity

and length of panicles, as well as between the panicle productivity and the grain number per panicle *(Özgen, 1993*).

The oat panicle productivity can be improved by an in-depth knowledge of critical phenological phases. Some authors have recorded the grain number per panicle before and after anthesis. The characters specific to the pre-anthesis phase were in a positive linear correlation with the panicle productivity and the grain number per panicle. The post-anthesis characters were correlated with a decrease in the grain number per panicle and their weight relative to external factors (*Finnan and Spink, 2017*).

Fertilization plays a very important role in achieving a larger grain number per panicle. The application of nitrogenous fertilizers and crop rotation contribute to an increase in the spike and grain numbers per panicle (*Rubia Diana Mantai et al., 2018*).

Studies on the stability of the grain number per panicle in different oat varieties show that this character is more stable than other characters, which, in contrast, exert a greater influence on the panicle productivity. The interaction between oat genotypes and annual climatic conditions is of crucial importance to the panicle productivity, the percentage of grain chaff and the protein content (*Dumlupinar Ziya et al., 2011*).

Upon comparing autumn and spring oats, it was found that grain production is higher in autumn oats on account of a larger spike number per panicle. Moreover, the fertility of spikelets is better, featuring two grains per spikelet. The productivity differences between autumn and spring oats are due to different grain numbers per panicle (*Crampton et al., 1997*).

The present study is aimed at assessing the stability of the grain number per panicle in a collection of autumn oat genotypes.

MATHERIAL AND METHOD

The present study was conducted under field conditions in Timisoara, Western Romania, over a period of three years (2015-2017). The first year of the experiment was characterised by favourable climate conditions. Rainfall was low in the spring of the second experimental year, whereas drought was prolonged in the third experimental year until early summer. Over the experimental period of three years, the temperatures recorded were close to the multi-year averages. A chernozemic soil was used in the experiment and the biological material analysed consisted of 73 genotypes of autumn oat, which were compared with the Romanian cultivar Florina. The experimental data were obtained by determining the grain number per panicle of each oat genotype under consideration. This method of assessing the stability of genotypes under different environmental conditions is based on the fact that different components of the genotype x environment interaction are linearly related and reflected in the characters of all the genotypes examined.

The relative adaptability of a genotype to different environmental conditions is based on three parameters: the average genotype performance, the genotype response to different environmental conditions (the regression coefficient) and the stability of genotype performance (regression deviations). According to the "static" concept, the Type I stability occurs provided the genotype performance is constant across the environment conditions considered (the regression coefficient bi = 0). Therefore, the "dynamic" Type II stability occurs provided the genotype response to the environment is parallel to the mean response of all the genotypes under consideration. The type III stability occurs provided the deviation from the regression line is small (*Annicchiarico, 2002; Bernardo, 2002*).

The following models were used for data processing in the present study: Finlay-Wilkinson, Hardwick-Wood, Muir and Wrike (*Ciulca, 2006*). For analyzing the genotype x environment interaction, a total of two components were taken into account: the heterogeneity of genetic variants and the imperfection of correlations. The relationship between the results of different methods for assessing the stability of the studied characters was established using the coefficient of concordance (*Muir et al., 1992*).

RESULTS AND DISCUSSION

On the basis of the data presented in Table 1, it can be observed that the highest Type I stability was recorded in the following oat genotypes: 4451, Chamois, Penwin, Emperor and Thonson (*Becker and Leon, 1988; Annicchiarico., 2002*). The lowest Type I stability relative to the grain number per main panicle was recorded in the following oat lines and cultivars: 4492, PA 522-23, 4482, Barra and Fergushon.

Table 1. Stability of the grain number/main panicle through (FINLAY-WILKINSON) the linear regression for the winter oat genotypes under consideration

No	Genotype	Average	Regression coefficient	Stability			Regression constant o	Deviation from regression
				Type I (rank)	Type III (rank)	Type II (rank)		
1	Florina (control)	47.17	1.476	54	49	34	-14.29	61.10
2	Norline	44.71	0.459	17	38	38,5	25.61	37.31
3	Arlingthon	36.34	0.823	28	22	18	2.06	10.31
4	Blamouth	33.16	0.587	22	30	26	8.72	24.02
5	CI 1908	29.45	0.515	19	53	37	8.01	69.65
6	Cimarron	28.47	0.883	34	65	5	-8.30	148.96
7	Crater	34.64	1.148	43	63	16	-13.18	118.04
8	Earlygrain	29.93	0.333	14	18	44	16.04	4.63
9	Excel	42.72	1.779	66	43	59	-31.36	49.60
10	Fergushon	44.88	2.169	69	68	63	-45.43	297.41
11	Fulwood	44.94	0.666	25	8	22	17.19	2.44
12	Jefferson	43.29	1.006	36	24	3	1.39	12.33
13	Le Conte	29.84	0.214	8	45	49	20.92	50.89
14	Nortex	37.82	1.086	41	1	11	-7.41	0.01
15	Suergrain	48.07	1.165	45	41	17	-0.43	44.88

16	Thonson	40.75	-0.160	5	26	69	47.41	13.38
17	Walken	37.16	1.021	38	17	1	-5.36	4.55
18	Compact	46.35	1.251	48	20	27	-5.76	6.86
19	Pennwin	41.54	0.128	3	37	62	36.21	35.11
20	2288	47.92	0.623	23	55	25	21.97	77.09
21	3378	54.75	1.623	61	7	53	-12.85	1.95
22	834-4-1-3	39.31	0.667	26	27	21	11.55	14.49
23	3412	36.59	-0.485	18	51	73	56.80	64.32
24	S Dak 40	63.93	1.453	53	5	33	3.43	0.94
25	3868	43.33	1.313	50	50	29	-11.35	63.47
26	Cocker 41-51	39.79	-0.195	6	42	70	47.91	46.17
27	4444	61.64	2.063	67	14	60	-24.27	3.90
28	4451	36.89	-0.085	1	32	66	40.41	26.64
29	4458	45.11	0.824	29	35	14	10.79	29.65
30	4472	31.26	0.263	12	19	46	20.31	5.57
31	4475	36.54	1.541	56	66	38,5	-27.63	193.98
32	4476	49.74	1.219	46	23	19	-1.01	11.44
33	4477	37.78	-0.225	9	58	71	47.16	87.89
34	4478	26.62	0.854	32	71	7,5	-8.94	348.61
35	4480	38.51	0.411	16	11	40	21.38	2.83
36	4482	45.85	2.317	71	67	67	-50.64	280.29
37	4483	43.94	1.653	63	57	56	-24.90	82.17
38	4484	28.91	0.826	30	13	12,5	-5.51	3.72
39	4488	28.83	0.542	21	2	32	6.25	0.04
40	4492	49.40	2.831	73	56	72	-68.50	79.93
41	5029	41.47	1.010	37	73	2	-0.59	673.01
42	5032	55.12	1.711	65	44	58	-16.14	49.94
43	Marrettos Anderson	46.86	1.619	60	9	52	-20.58	2.50
44	8276	45.62	1.566	57	39	41	-19.57	40.45
45	PA 522-7	47.71	1.598	58	64	42	-18.85	145.17
46	PA 522-23	44.41	2.428	72	15	68	-56.71	4.39
47	PA 621-3274	52.59	2.168	68	21	61	-37.70	7.66
48	PA 724-2580	33.82	0.840	31	6	12,5	-1.14	1.42
49	PA 725-2154	45.70	0.723	27	4	20	15.59	0.06
50	PA 725-4743	45.38	1.086	42	62	10	0.16	116.52
51	PA 725-4787	42.12	0.410	15	69	43	25.06	327.16
52	PA 725-6113	34.62	0.250	11	33	47	24.23	27.18
53	PA 822-818	48.59	0.935	35	48	4	9.64	53.59
54	ARK 0151-61	44.17	1.321	52	10	31	-10.84	2.73
55	AR 104-18	47.88	1.221	47	29	24	-2.96	20.29
56	Marys Quest	39.44	0.534	20	12	35	17.21	3.06
57	Wodan	52.56	1.635	62	3	54	-15.52	0.04
58	Gospodarski 48	31.43	0.232	10	28	48	21.76	17.96
59	5183	41.28	1.046	39	61	6	-2.27	99.17
60	Tripolis	51.64	1.317	51	52	30	-3.19	65.86
61	Krusevac	40.28	1.607	59	16	50	-26.61	4.52
62	Boer	45.02	1.663	64	47	57	-24.25	53.37
63	Algerian	27.78	1.058	40	72	9	-16.26	397.35
64	Mirabel	39.78	1.265	49	60	28	-12.89	96.80
65	Gerald	39.95	1.526	55	54	36	-23.62	73.75
66	Nuptiale	35.94	0.200	7	36	51	27.60	33.70
67	Solva	39.79	0.633	24	25	23	13.44	13.15
68	Valiant	48.97	1.148	44	40	15	1.15	41.08
69	Barra	56.75	2.289	70	46	64	-38.59	52.20
70	Carrie	44.06	0.881	33	31	7,5	7.39	24.14
71	Krypton	31.15	0.272	13	59	45	19.82	93.29
72	Chamois	32.48	0.091	2	70	65	28.69	335.38
73	Emperor	37.54	0.130	4	34	55	32.14	28.39

The highest Type II stability (the coefficients of regression close to 1) was recorded in the following oat cultivars and lines: Walken, 5029, Jefferson, PA 822-818 and Cimarron. The lowest dynamic stability was observed in the following genotypes: 3412, 4492, 4477, Cocker 41-51 and Thonson. The highest Type III stability was observed in the following genotypes: Nortex, 4488, Wodan, PA 725-2154 and S Dak 40. The genotypes 5029, 4478, Algerian, Chamois and PA 725-4787, with a reduced type III stability, exhibited significant differences in the grain number per main panicle during the three-year experimental period.

Considering the low and insignificant values of the F test for the regression heterogeneity, it can be concluded that the regression model is suitable for studying the stability of this character and estimates adequately the performance of cultivars and lines over the three-year experimental period. It can also be argued that there are significant differences between the genotypes examined and experimental years relative to the average values of the grain number per main panicle across the oat genotypes under consideration (Table 2).

Table 2. Linear regression analysis of variance (HARDWICK – WOOD) for the grain number/main panicle of the winter oat genotypes under consideration during 2001-2004

Source of variability	SS	DF	MS	F
Total	50714	218		
Genotypes	13947	72	193,72	F = 2.65**
Years	23963	2	11981	F = 164.13**
Genotype x years	16803	144	116,69	F = 1.59*
Regression heterogeneity	7481	72	103,90	
Error	5322	72	73,92	

*; ** Significant at $P \leq 0.05$ and $P \leq 0.01$, respectively

The lowest significant values of ecovalence and a high stability of the grain number per main panicle were recorded in the following genotypes: Nortex, Walken, PA 724-2580, Jefferson and 4484. High values of the ecological valence, indicating a marked instability of the character under different climatic conditions, were observed in the following cultivars: 4492, 4482, 3412, Fergushon and PA 522-23. On balance, the high values of ecovalence obtained, or the reduced stability of this character, are associated with higher values of the grain number per main panicle. (Table 3)

Table 3. Stability of grain number/main panicle through (WRIKE) the ecovalence values of the winter oat genotypes under consideration

No	Genotype	Average	Ecov.	Ecov. vari.	F test	Stab. rank
1	Florina (control)	47.17	135.43	388.05	11.70**	37
2	Norline	44.71	133.46	53.21	1.85	36
3	Arlingthon	36.34	20.56	116.43	21.57**	6
4	Blamouth	33.16	80.04	68.55	4.71**	23
5	CI 1908	29.45	146.87	78.36	1.25	39
6	Cimarron	28.47	153.46	202.44	1.72	42
7	Crater	34.64	125.28	275.50	3.67*	31
8	Earlygrain	29.93	150.48	20.56	7.88**	40
9	Excel	42.72	248.92	544.39	20.95**	51
10	Fergushon	44.88	745.91	920.81	5.19**	70
11	Fulwood	44.94	38.96	74.13	59.58**	13
12	Jefferson	43.29	12.31	172.29	26.91**	4
13	Le Conte	29.84	253.60	32.98	0.30	52
14	Nortex	37.82	2.46	193.71	25335**	1
15	Suergrain	48.07	53.78	245.05	9.92**	17
16	Thonson	40.75	151.95	10.88	0.63	41
17	Walken	37.16	4.70	173.36	75.11**	2
18	Compact	46.35	27.61	260.45	74.87**	9
19	Pennwin	41.54	284.72	20.25	0.15	56
20	2288	47.92	123.71	102.29	1.65	30
21	3378	54.75	129.54	433.55	441.45**	34
22	834-4-1-3	39.31	50.95	80.21	10.07**	16
23	3412	36.59	788.52	70.82	1.20	71
24	S Dak 40	63.93	68.30	346.98	735.01**	20
25	3868	43.33	95.65	314.72	8.92**	24
26	Cocker 41-51	39.79	514.99	29.33	0.27	64
27	4444	61.64	374.96	700.62	358.05**	59
28	4451	36.89	412.81	14.50	0.09	61
29	4458	45.11	39.82	126.28	7.52**	14
30	4472	31.26	183.85	14.15	4.07*	44
31	4475	36.54	290.05	486.74	4.02*	57
32	4476	49.74	27.14	249.50	42.62**	8
33	4477	37.78	580.71	52.27	0.19	65
34	4478	26.62	355.60	294.04	0.69	58
35	4480	38.51	116.57	29.19	19.60**	27
36	4482	45.85	849.93	1021.52	6.29**	72
37	4483	43.94	222.18	489.60	10.92**	49
38	4484	28.91	13.62	113.96	60.13**	5
39	4488	28.83	68.80	48.30	2019**	21
40	4492	49.40	1190.98	1355.81	32.92**	73
41	5029	41.47	673.04	503.95	0.50	68
42	5032	55.12	216.09	505.71	19.25**	48
43	Marr. Ander.	46.86	128.48	431.72	343.34**	33
44	8276	45.62	145.49	422.56	19.89**	38
45	PA 522-7	47.71	262.70	491.90	5.78**	53
46	PA 522-23	44.41	674.08	970.03	440.17**	69
47	PA 621-3274	52.59	455.67	775.45	201.27**	63
48	PA 724-2580	33.82	9.87	116.40	163.12**	3
49	PA 725-2154	45.70	25.24	85.84	2534**	7
50	PA 725-4743	45.38	118.96	251.84	3.32*	28
51	PA 725-4787	42.12	441.54	191.14	0.17	62
52	PA 725-6113	34.62	212.00	23.82	0.75	47
53	PA 822-818	48.59	54.97	170.38	5.36**	18
54	ARK 0151-61	44.17	36.58	287.82	209.65**	12
55	AR 104-18	47.88	36.31	254.80	24.11**	11
56	Marys Quest	39.44	74.38	48.31	30.55**	22
57	Wodan	52.56	132.39	438.76	21514**	35
58	Gospod. 48	31.43	211.47	17.83	0.99	46
59	5183	41.28	99.87	229.12	3.62*	26
60	Tripolis	51.64	98.80	317.51	8.64**	25
61	Krusevac	40.28	125.28	425.88	187.31**	32
62	Boer	45.02	197.86	480.85	17.02**	45
63	Algerian	27.78	398.45	382.33	0.92	60
64	Mirabel	39.78	119.87	311.07	5.43**	29
65	Gerald	39.95	164.74	419.33	10.37**	43
66	Nuptiale	35.94	243.71	23.43	0.39	50
67	Solva	39.79	57.45	72.27	9.99**	19
68	Valiant	48.97	48.30	236.94	10.53**	15
69	Barra	56.75	597.96	886.37	32.96**	66
70	Carrie	44.06	28.82	139.36	10.54**	10
71	Krypton	31.15	267.20	58.80	0.26	54
72	Chamois	32.48	606.56	169.06	0.01	67
73	Emperor	37,54	277,10	16,95	0,19	55

**; ** Significant at $P \leq 0.05$ and $P \leq 0.01$, respectively*

An analysis of the genotype x environment interaction (Table 4) showed that the highest stability of the grain number per main panicle, i.e. a low genotype x environment interaction, was recorded in the following genotypes: Nortex, Walken, Jefferson, PA 724-2580, 4484 and PA 725-2154. A high genotype x environment interaction, associated with a high instability of this character, was observed in the the genotypes 4492, 4482, 3412 and Fergushon.

In this case, a total of 53.10 % of the genotype x environment interaction is due to the heterogeneity of variants. The heterogeneity of variants and imperfect correlations can be effectively used for assessing the stability of the grain number per main panicle. Relative to the variance heterogeneity, the most stable values of the grain number per panicle were recorded in the varieties Cimarron, Nortex, Suergrain and Valiant, as well as in the lines PA 725-4787 and 5183.

There is a close concordance between the results of the four models used for assessing the stability of the grain number per main panicle. According to these models, the greatest stability of this character was recorded in the following genotypes: Nortex, Walken, PA 725-2154, Jefferson and Fulwood. A great instability was observed in the following cultivars and lines: 4482, 4492, Fergushon, Barra and PA 522-23. (Table 5)

Table 4. Stability of the grain number/ main panicle through (MUIR) the heterogeneous variances (HV) and imperfect correlations (IC) for the winter oat genotypes under consideration during 2001-2004

No	Genotype	Average	SS		SS		SS	
			(HV)	(%)	(IC)	(%)	(GE)	(%)
1	Florina (mt.)	47.17	85.42	0.96	97.39	1.24	182.81	1.09
2	Norline	44.71	116.98	1.31	64.84	0.82	181.82	1.08
3	Arlingthon	36.34	76.94	0.86	48.43	0.61	125.37	0.75
4	Blamouth	33.16	103.22	1.16	51.89	0.66	155.11	0.92
5	CI 1908	29.45	96.11	1.08	92.41	1.17	188.53	1.12
6	Cimarron	28.47	61.40	0.69	130.42	1.65	191.82	1.14
7	Crater	34.64	64.46	0.72	113.27	1.44	177.73	1.06
8	Earlygrain	29.93	165.85	1.86	24.49	0.31	190.33	1.13
9	Excel	42.72	134.45	1.51	105.11	1.33	239.55	1.43
10	Fergushon	44.88	303.73	3.40	184.33	2.34	488.06	2.90
11	Fulwood	44.94	99.04	1.11	35.53	0.45	134.57	0.80
12	Jefferson	43.29	63.81	0.72	57.45	0.73	121.26	0.72
13	Le Conte	29.84	142.58	1.60	99.31	1.26	241.89	1.44
14	Nortex	37.82	61.84	0.69	54.49	0.69	116.32	0.69
15	Suergrain	48.07	61.90	0.69	80.08	1.02	141.98	0.84
16	Thonson	40.75	192.67	2.16	149.90	1.90	342.57	2.04
17	Walken	37.16	63.88	0.71	53.76	0.68	117.44	0.70
18	Compact	46.35	62.99	0.71	65.91	0.84	128.90	0.77
19	Pennwin	41.54	166.56	1.87	90.89	1.15	257.45	1.53
20	2288	47.92	82.78	0.93	94.17	1.19	176.95	1.05
21	3378	54.75	97.76	1.10	82.11	1.04	179.86	1.07
22	834-4-1-3	39.31	94.90	1.06	45.67	0.58	140.57	0.84
23	3412	36.59	101.48	1.14	407.87	5.18	509.35	3.03
24	S Dak 40	63.93	76.00	0.85	73.24	0.93	149.24	0.89
25	3868	43.33	69.94	0.78	92.97	1.18	162.92	0.97
26	Cocker 41-51	39.79	148.59	1.67	224.00	2.84	372.59	2.22
27	4444	61.64	198.02	2.22	104.56	1.33	302.57	1.80
28	4451	36.89	181.26	2.03	140.24	1.78	321.50	1.91
29	4458	45.11	73.58	0.82	61.42	0.78	135.00	0.80
30	4472	31.26	182.28	2.04	24.74	0.31	207.01	1.23
31	4475	36.54	114.31	1.28	145.81	1.85	260.12	1.55
32	4476	49.74	62.17	0.70	66.50	0.84	128.66	0.77
33	4477	37.78	117.94	1.32	287.51	3.65	405.45	2.41
34	4478	26.62	66.77	0.75	226.12	2.87	282.89	1.74
35	4480	38.51	148.82	1.67	24.55	0.31	173.38	1.03
36	4482	45.85	356.70	4.00	183.36	2.33	540.95	3.21
37	4483	43.94	115.26	1.29	110.92	1.41	226.18	1.35
38	4484	28.91	77.87	0.87	44.03	0.56	121.90	0.73
39	4488	28.83	122.24	1.37	27.25	0.35	149.49	0.89
40	4492	49.40	547.44	6.14	158.14	2.01	705.58	4.20
41	5029	41.47	120.10	1.35	331.51	4.21	451.61	2.69
42	5032	55.12	120.70	1.35	102.43	1.30	223.14	1.33
43	Marr. Ander.	46.86	97.22	1.09	82.11	1.04	179.33	1.07
44	8276	45.62	94.61	1.06	93.23	1.18	187.84	1.12
45	PA 522-7	47.71	116.02	1.30	130.42	1.65	246.44	1.47

46	PA 522-23	44.41	329.31	3.69	122.82	1.56	452.13	2.69
47	PA 621-3274	52.59	232.15	2.60	110.77	1.41	342.93	2.04
48	PA 724-2580	33.82	76.95	0.86	43.08	0.55	120.03	0.71
49	PA 725-2154	45.70	91.40	1.02	36.31	0.46	127.71	0.76
50	PA 725-4743	45.38	62.32	0.70	112.25	1.42	174.57	1.04
51	PA 725-4787	42.12	62.00	0.69	273.86	3.47	335.86	2.00
52	PA 725-6113	34.62	158.88	1.78	62.22	0.79	221.09	1.32
53	PA 822-818	48.59	64.06	0.72	78.52	1.00	142.58	0.85
54	ARK 0151-61	44.17	65.94	0.74	67.44	0.86	133.38	0.79
55	AR 104-18	47.88	62.54	0.70	70.71	0.90	133.25	0.79
56	Marys Quest	39.44	122.23	1.37	30.05	0.38	152.28	0.91
57	Wodan	52.56	99.22	1.11	82.01	1.04	181.29	1.08
58	Gospod. 48	31.43	172.32	1.93	48.50	0.62	220.82	1.31
59	5183	41.28	61.25	0,.69	103.78	1.32	165.03	0.98
60	Tripolis	51.64	70.42	0.79	94.02	1.19	164.49	0.98
61	Krusevac	40.28	95.45	1.07	82.19	1.04	177.73	1.06
62	Boer	45.02	112.37	1.26	101.65	1.29	214.02	1.27
63	Algerian	27.78	84.01	0.94	230.31	2.92	314.32	1.87
64	Mirabel	39.78	69.34	0.78	105.68	1.34	175.03	1.04
65	Gerald	39.95	93.70	1.05	103.76	1.32	197.46	1.18
66	Nuptiale	35.94	159.69	1.79	77.26	0.98	236.95	1.41
67	Solva	39.79	100.39	1.13	43.43	0.55	143.82	0.86
68	Valiant	48.97	61.50	0.69	77.74	0.99	139.24	0.83
69	Barra	56.75	286.21	3.21	127.86	1.62	414.07	2.46
70	Carrie	44.06	69.89	0.78	59.61	0.76	129.50	0.77
71	Krypton	31.15	111.53	1.25	137.17	1.74	248.69	1.48
72	Chamois	32.48	64.23	0.72	354.14	4.49	418.37	2.49
73	Emperor	37.54	174.56	1.96	79.08	1.00	253.64	1.51
TOTAL			8922.37	53.10	7881.05	46.90	16803.42	100.00

HV - Heterogenity variance; IC - Imperfect correlations; GE - Genotype x environment interaction; SS – Sum square

Table 5. Concordance of ranks of different stability estimation models for the grain number/main panicle of the winter oat genotypes under consideration

No.	Genotype	Average	Ranks stability				Amounts ranks	SS_R
			Type I	Type II	Type III	Ecovalence		
1	Florina (mt.)	47.17	54	34	49	37	174	676
2	Norline	44.71	17	38.5	38	36	129,5	342.25
3	Arlingthon	36.34	28	18	22	6	74	5476
4	Blamouth	33.16	22	26	30	23	101	2209
5	CI 1908	29.45	19	37	53	39	148	0
6	Cimarron	28.47	34	5	65	42	146	4
7	Crater	34.64	43	16	63	31	153	25
8	Earlygrain	29.93	14	44	18	40	116	1024
9	Excel	42.72	66	59	43	51	219	5041
10	Fergushon	44.88	69	63	68	70	270	14884
11	Fulwood	44.94	25	22	8	13	68	6400
12	Jefferson	43.29	36	3	24	4	67	6561
13	Le Conte	29.84	8	49	45	52	154	36
14	Nortex	37.82	41	11	1	1	54	8836
15	Suergrain	48.07	45	17	41	17	120	784
16	Thonson	40.75	5	69	26	41	141	49
17	Walken	37.16	38	1	17	2	58	8100
18	Compact	46.35	48	27	20	9	104	1936
19	Pennwin	41,.54	3	62	37	56	158	100
20	2288	47.92	23	25	55	30	133	225
21	3378	54.75	61	53	7	34	155	49
22	834-4-1-3	39.31	26	21	27	16	90	3364
23	3412	36.59	18	73	51	71	213	4225
24	S Dak 40	63.93	53	33	5	20	111	1369
25	3868	43.33	50	29	50	24	153	25

26	Cocker 41-51	39.79	6	70	42	64	182	1156
27	4444	61.64	67	60	14	59	200	2704
28	4451	36.89	1	66	32	61	160	144
29	4458	45.11	29	14	35	14	92	3136
30	4472	31.26	12	46	19	44	121	729
31	4475	36.54	56	38,5	66	57	217,5	4830.25
32	4476	49.74	46	19	23	8	96	2704
33	4477	37.78	9	71	58	65	203	3025
34	4478	26.62	32	7,5	71	58	168,5	420.25
35	4480	38.51	16	40	11	27	94	2916
36	4482	45.85	71	67	67	72	277	16641
37	4483	43.94	63	56	57	49	225	5929
38	4484	28.91	30	12,5	13	5	60,5	7656.25
39	4488	28.83	21	32	2	21	76	5184
40	4492	49.40	73	72	56	73	274	15876
41	5029	41.47	37	2	73	68	180	1024
42	5032	55.12	65	58	44	48	215	4489
43	Marre. Ande.	46.86	60	52	9	33	154	36
44	8276	45.62	57	41	39	38	175	729
45	PA 522-7	47.71	58	42	64	53	217	4761
46	PA 522-23	44.41	72	68	15	69	224	5776
47	PA 621-3274	52.59	68	61	21	63	213	4225
48	PA 724-2580	33.82	31	12,5	6	3	52,5	9120.25
49	PA 725-2154	45.70	27	20	4	7	58	8100
50	PA 725-4743	45.38	42	10	62	28	142	36
51	PA 725-4787	42.12	15	43	69	62	189	1681
52	PA 725-6113	34.62	11	47	33	47	138	100
53	PA 822-818	48.59	35	4	48	18	105	1849
54	ARK 0151-61	44.17	52	31	10	12	105	1849
55	AR 104-18	47.88	47	24	29	11	111	1369
56	Marys Quest	39.44	20	35	12	22	89	3481
57	Wodan	52.56	62	54	3	35	154	36
58	Gospodarski 48	31.43	10	48	28	46	132	256
59	5183	41.28	39	6	61	26	132	256
60	Tripolis	51.64	51	30	52	25	158	100
61	Krusevac	40.28	59	50	16	32	157	81
62	Boer	45.02	64	57	47	45	213	4225
63	Algerian	27.78	40	9	72	60	181	1089
64	Mirabel	39.78	49	28	60	29	166	324
65	Gerald	39.95	55	36	54	43	188	1600
66	Nuptiale	35.94	7	51	36	50	144	16
67	Solva	39.79	24	23	25	19	91	3249
68	Valiant	48.97	44	15	40	15	114	1156
69	Barra	56.75	70	64	46	66	246	9604
70	Carrie	44.06	33	7,5	31	10	81,5	4422.25
71	Krypton	31.15	13	45	59	54	171	529
72	Chamois	32.48	2	65	70	67	204	3136
73	Emperor	37.54	4	55	34	55	148	0
Sum			2701	2701	2701	2701	10804	223496

*SS_R – Regression sum square; χ^2 =124.12***; $\chi^2_{0.1\%}$ =112,32; *** Significant at P ≤ 0.001*

Relative to all the oat genotypes under consideration, the number of genotypes with a good stability of the grain number per panicle is small. The results obtained are consistent with the results of a study on the character stability in oats including 11 oat genotypes from India examined at six different locations. Of the 11 genotypes evaluated, only three had a good panicle stability, which was also tested according to the grain number per panicle (*Uzma et al., 2017*). The oat character stability can be assessed by examining a specific character over different periods of time and at different locations. Such combined studies are more selective, highlighting the genotypes with the highest degree of adaptation to different stress conditions. A plant's productivity-stability analysis aims to verify the plant's response to the environmental-genotype interactions. Through such elaborate studies, it has been found that approximately two out of ten oat genotypes exhibit a good stability (*Mushtaq et al., 2013*).

CONCLUSION

The number of grains per panicle is a major component of plant productivity. The values of this character vary on an annual

basis. The varieties Jefferson, Carrie and Florina, as well as the lines 4458, PA 725-4743 and PA 822-818, were found to exhibit a high dynamic stability associated with high values of the grain number per panicle. Oat genotypes with a low variability in the grain number per panicle under different environmental conditions, such as the Thomson, Penwin and Cocker 41-51 cultivars, are of great importance to breeding programs. Relative to all the processing models employed, the greatest stability of this character was recorded in the following genotypes: Nortex, Walken, PA 725-2154, Jefferson and Fulwood.

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Received: 20. 02. 2019. Accepted: 28. 03. 2019.