

CHARACTERIZATION FOR PLANT HEIGHT AND FLOWERING DATE IN THE BIOLOGICAL SPECIES OAT¹

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ABSTRACT - The use of wild oat races in artificial hybridization with cultivated oat (*Avena sativa* L.) has been used as a way of increasing the variability. This work aimed to identify the variability for plant height and flowering date of groups of cultivated oat genotypes, wild introductions of *A. fatua* L. and segregating populations of natural crosses between *A. sativa* and *A. fatua*. Wide genetic variability was observed for both traits in the groups and between them. The wild group of *A. fatua* L. showed high plants with early maturity, but in the segregating group there was reduced plant height and early maturity. The wild introductions of *A. fatua* L. studied in this work can be used in oat breeding programs to increase genetic variability by transferring specific characters into the cultivated germ plasm.

Index terms: plant breeding, *Avena fatua*, segregating populations.

CARACTERIZAÇÃO DA ESTATURA DE PLANTA E DATA DE FLORESCIMENTO NA ESPÉCIE BIOLÓGICA AVEIA

RESUMO - A utilização de raças silvestres em hibridações com o grupo cultivado em aveia (*Avena sativa* L.) tem sido fonte de incremento da variabilidade genética. Desta forma, o presente trabalho foi desenvolvido com o objetivo de identificar e caracterizar a variabilidade genética dos caracteres morfo-fisiológicos estatura de planta e dias da emergência à floração em grupos de genótipos cultivados de aveia, introduções silvestres de *A. fatua* L., e em populações segregantes dos cruzamentos naturais de *A. sativa* x *A. fatua*. Ampla variabilidade genética foi revelada para os caracteres avaliados tanto dentro como entre os grupos. O grupo silvestre *A. fatua* demonstrou plantas de elevada estatura e precoces. Foi possível encontrar populações segregantes de *A. sativa* x *A. fatua* com reduzida estatura e precocidade. As introduções silvestres de *A. fatua* avaliadas neste trabalho podem ser utilizadas em programas de melhoramento para incrementar a variabilidade genética, pela transferência de caracteres específicos para o germoplasma cultivado.

Termos para indexação: melhoramento vegetal, *Avena fatua*, populações segregantes.

INTRODUCTION

Avena fatua L. is an hexaploid wild oat ($2n=6x=42$) known as a noxious weedy plant from North America and other grain producing regions of the world. It is morphologically distinguished from cultivated oat by the presence of long geniculate awns and by seed shattering via abscission of individual florets. The genotypes frequently have colored dark seeds (gray,

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brown or red), and pubescence on the lemma rachilla and base of the seeds (Luby & Stuthman, 1983). In Brazil, it has probably been introduced as impurity of cereal grains. In the South, it occurs spontaneously, as weed or in the edge of roads. Although hexaploidy in oat has been characterized by self-pollination, most researchers related natural hybrids between cultivated and silvester races (Derick, 1933). In the Southern Brazil, natural hybrids of *A. sativa* x *A. sterilis* L. have been identified (Dillenburg, 1984).

The introduction of genes for low plant height on cultivated genotypes resulted in enhancement on grain yield, because lodging reduction and harvest index improvement. In oat, the effects of genes for low plant height have been limited because of the use of this cereal for many purposes (grain and forage) and most of all, cultivation on low fertility soils, which limits the height of the genotypes (Federizzi & Qualset, 1989). Increasing in plant breeding efforts and environment adaptation led to development of genotypes with modified morpho-physiological traits as low plant height, early maturity and high fertility (grains/panicle) which determined the increase in grain yield potential of new cultivars (Carvalho & Federizzi, 1989).

Southern Brazil cultivation system consists of two crops sown each year in succession, in summer and winter; as a consequence the flowering date adjustment between crops is an important subject. The winter crop must be of early maturity, so the summer crop (soybean or maize) will not be delayed. Earliness in oat can be also used to avoid diseases such as crown and leaf rust, which cause great damages to grain yield (Bertagnolli, 1992). Flowering date adequate to the production system induced an expressive grain yield progress of crops sown after the usual period. This earliness was reached with UFRGS-7 and UFRGS-8, the earliest commercial cultivars in 1987 (Carvalho & Federizzi, 1989). For wheat, earliness and low plant height were determinant factors for grain yield enhancement, probably because the adjustment to light and temperature conditions (Briggle & Vogel, 1968). Bertagnolli (1992) related genetic variability for earliness in oat germ plasm and suggested to transfer these genes into new genotypes. Besides, the

existence of few genes for this trait and its genetic effect would favor selection for early genotypes in segregating populations.

Using oat wild races in breeding programs deserves a characterization of the genetic variability.

The purpose of this study was to identify and characterize genetic variability for plant height and flowering date of cultivated oat genotypes, introductions of *A. fatua*, and segregating populations of natural crosses between *A. sativa* and *A. fatua*.

MATERIAL AND METHODS

The experiment was conducted in 1994 and 1995 at UFRGS Research Station (EEA/UFRGS), in Eldorado do Sul, RS. The material was manually sown on rows 0.3 m apart and 3 m long with 10 seeds for each row.

Five cultivated genotypes (UFRGS-7, UFRGS-14, UFRGS-17, UFRGS-91905 and UPF-16), five introductions of *A. fatua* (I-93041, I-93033, I-93056, I-93058 and I-93066), five populations, F₁ in 1994 and F₂ in 1995 (I-93047, I-93048, I-93049, I-93052 and I-93069), and ten segregating populations F₂ in 1994 and F₃ in 1995 (I-93014, I-93027, I-93029, I-93034, I-93050, I-93060, I-93070, I-93072, I-93073 and I-93113), were used in this study.

The availability of genetic material in 1994 restricted the number of rows to two per genotype per block. The experiment was conducted in a randomized complete block design with two replications. In 1995, the cultivated, wild, F₂, and F₃ groups were placed in a single block, with five rows for both the cultivated and wild groups, and ten rows for both the F₂ and F₃ groups.

Evaluation of morpho-physiological traits were made for all the individual plants available. Plant height and flowering date were traits measured in both years.

The results were analyzed using analysis variance for each group and among them. Means comparison was made using Duncan's test at 5% level for each group and among them.

RESULTS AND DISCUSSION

For plant height, significant differences were detected within each group in 1994 and 1995, pointing to broad genetic variability among the genotypes tested (Table 1). Three different classes for plant height were formed for cultivated groups in 1994, where UFRGS-91905 had the highest plant height,

TABLE 1. Means for plant height (cm) for genotypes within group and among groups of cultivated and wild oat, hybrids F₁ (1994) and F₂ (1995) and segregating F₂ (1994) and F₃ (1995). Eldorado do Sul, RS, 1994/1995¹.

Group	Genotype	Plant height	
		1994	1995
Cultivated	UFRGS-91905	88.81A	90.79B
	UFRGS-14	80.94B	99.16A
	UPF-16	76.85C	99.95A
	UFRGS-17	76.82C	100.72A
	UFRGS-7	76.80C	99.90A
Means		80.00a	98.35d
C.V. (%)		4.24	6.29
Wild	I-93041	81.95A	124.12B
	I-93066	81.00AB	128.59A
	I-93058	80.81AB	119.00C
	I-93033	80.08AB	124.02B
	I-93056	77.29B	122.70BC
Means		80.07a	123.78c
C.V. (%)		6.65	6.64
F ₁ and F ₂	I-93049	84.60A	144.29A
	I-93048	81.50AB	125.14C
	I-93052	81.03B	121.98D
	I-93047	78.79BC	129.10B
	I-93069	76.40C	121.44D
Means		80.18a	127.76a
C.V. (%)		7.69	7.76
F ₂ and F ₃	I-93034	89.78A	115.60E
	I-93072	85.96B	125.59D
	I-93060	83.18BC	133.32C
	I-93073	82.54BCD	127.89D
	I-93029	82.46BCD	135.21BC
	I-93050	79.64CDE	138.55B
	I-93014	79.36CDE	143.12A
	I-93070	78.74DE	127.15D
	I-93027	76.44EF	102.75F
	I-93113	72.75F	104.48F
	Means		81.05a
Group-CV (%)		7.09	8.78
C.V. (%)		8.12	9.68

¹ Means followed by the same capital letter do not differ significantly by Duncan's test 5%, among genotypes within the same group; means followed by the same minuscule letter do not differ significantly by Duncan's test 5%, among the groups within each year.

about 12 cm beyond the lowest genotype (UFRGS-7). In 1995, the analysis pointed to two distinct groups, where UFRGS-91905 showed the lowest plant height of the group. The mean for the cultivated group in 1995 was 18.35 cm beyond the mean of 1994 (Table 1).

Wild introductions of *A. fatua* L. demonstrated in 1994 narrow amplitude of variation (4.66 cm) when

compared to other groups. The introduction I-93041 showed the highest mean of the group, differing statistically only from I-93056. In 1995, the introductions were taller than 1994, about 43.71 cm, while I-93058 revealed the lowest height of the group.

Two of the hybrid F₁ populations showed the highest plant height (I-93049 and I-93048). In 1995, the I-93049 F₂ population was the tallest population. Mean for plant height in 1995 was 47.58 cm higher than in 1994 (Table 1).

Among the 10 segregating F₂ populations in 1994 (Table 1), I-93034 showed the highest mean and the I-93113 the lowest mean, differing statistically from the remainder populations. In 1995 there was a modification in the behavior of segregating F₃ populations, where I-93014 and I-93113 demonstrated the highest and lowest plant height among the groups, respectively.

The different oat groups analyzed in 1994 were not significantly distinct among them for plant height. In 1995, the lowest plant height was observed in the cultivated group, and the highest in segregating F₂ and F₃ populations (Table 1).

For flowering date, estimated means for the cultivated group in 1994 showed distinct classes (Table 2). UFRGS-17 had the highest mean, 15.13 days beyond the earliest genotype of the group (UFRGS-91905). In 1995, results pointed to a reversion of the genotype values, when compared to 1994. UFRGS-91905 had the highest mean, 10.81 days later than UFRGS-17, the earliest of the group. Cultivated genotypes had increased 17.05 days in the means of the two years (Table 2).

Three different classes were observed for wild introductions in 1994 (Table 2), where I-93041 had the lowest value for flowering date, 19.18 days earlier than the later introduction (I-93066). In 1995, the ranking of the genotypes for this trait was modified, I-93058 was the earliest and I-93066, I-93033, I-93041 the latest in the group. Results also pointed out reduced variation among introductions, when compared to 1994.

For hybrid F₁ populations, two distinct classes were formed for flowering date in 1994 (Table 2), where the I-93048 population had the lowest mean for this trait, with 12.12 days earlier than the late population I-93049. In 1995, the same ranking was obtained for

TABLE 2. Means for flowering date (days) for genotypes within group and among groups of cultivated and wild oat, hybrids F₁ (1994) and F₂ (1995) and segregating F₂ (1994) and F₃ (1995). Eldorado do Sul/ RS, 1994/1995¹.

Group	Genotype	Flowering date	
		1994	1995
Cultivated	UFRGS-17	82.50A	87.19D
	UPF-16	76.73B	89.97C
	UFRGS-14	74.69BC	95.32B
	UFRGS-7	71.80C	90.20C
	UFRGS-91905	67.37D	98.00A
Means		74.78c	91.83b
C.V. (%)		9.73	3.17
Wild	I-93066	100.75A	89.00A
	I-93058	97.37AB	81.31C
	I-93033	95.00AB	89.00A
	I-93056	89.58BC	85.70B
	I-93041	81.57C	88.57A
Means		91.83b	86.89d
C.V. (%)		12.73	4.91
F ₁ and F ₂	I-93049	97.44A	97.93A
	I-93047	93.70A	95.55B
	I-93069	87.74B	94.24C
	I-93052	86.93B	92.10C
	I-93048	85.32B	94.75B
Means		89.93b	94.24a
C.V. (%)		12.58	4.70
F ₂ and F ₃	I-93073	108.04A	95.19AB
	I-93070	106.22A	88.11C
	I-93060	104.46A	88.59C
	I-93029	104.00A	87.08C
	I-93014	103.50A	93.19B
	I-93050	99.64AB	87.23C
	I-93072	92.32BC	93.86AB
	I-93034	89.30CD	95.94A
	I-93027	82.02DE	83.92D
	I-93113	78.19E	82.70D
Means		95.77a	89.60c
Group-C.V. (%)		13.21	6.98
C.V. (%)		14.58	8.57

¹ Means followed by the same capital letter do not differ significantly by Duncan's test 5%, among genotypes within the same group; means followed by the same minuscule letter do not differ significantly by Duncan's test 5%, among the groups within each year.

F₂ populations, except to I-93047 population which demonstrated an intermediate classification. An enhancement for flowering date was observed through the means of the groups obtained from 1994 and 1995.

Segregating F₂ populations showed broad genetic variability for flowering date. I-93113 population had

the lowest mean for this trait, 29.85 days earlier than I-93073, the late population of the group. In 1995, segregating F₃ population, I-93113 and I-93027 had maintained the ranking of 1994, with 13.24 and 12.02 days earlier than I-93034, the late population.

The intermediate similar behavior of plant height among oat groups in 1994 and the modified ranking of the genotypes from 1994 to 1995 within groups may be explained by environment influence. Great genetic variability was detected within and among the studied groups, with the lowest plant height from cultivated groups explained by strong selection pressure made by breeding programs for reduction of this trait. Carvalho & Federizzi (1989) suggested that advances in yield of oat were obtained through adjusted selection procedures to the Southern Brazilian environment conditions, primarily plant height reduction, earliness and fertility enhancement (grains/panicle). On the other hand, wild introductions of *A. fatua* showed tall plants, probably because of absence of artificial selection for this group or absence of genes for reduced plant height in the studied group. Luby & Stuthman (1983), when evaluating wild introductions of *A. fatua* for agronomic traits had also found genotypes taller than cultivated genotypes. Plant height in the *A. fatua* group is an important source of maintenance and surviving for wild races, since higher plants are benefited in environment competition. These results agree with those from Pfeifer & Carvalho (1981), who demonstrated that tall wheat genotypes exercise strong competition over plants with reduced height, leading to a progressive elimination of short individuals, when artificial selection is absent.

Although the intermediate plant height of segregating F₃ populations in 1995 had been higher than the cultivated group, some of these populations (I-93113, I-93027 and I-93034) present short plants which can be explained by genetic recombination between parents of these populations, resulting in a decreasing of plant height, facilitating its utilization in breeding programs.

For number of days to flowering, a narrow variation within groups was observed. The distribution of frequency pointed out that wild

introductions of *A. fatua* evaluated had most of the plants with the lowest number of days to flowering. The introduction I-93058 was the earliest among genotypes, probably because the reduced number of leaves, which can be considered as a strong source of genes for earliness. For wheat, Wobeto (1994) also observed that reduced number of days to flowering in BR 35 was related to low necessity of heat unit, reduced filocron and higher index of leaves emergence. For oat, Suneson (1967) transferred earliness and fast development from wild introductions of *A. fatua* to Rapida cultivar. For segregating F₂ populations, none presented earliness for flowering date, probably because of the genetic similarity between parents which originated those populations or the absence of enough recombination for expression of earliness. Nevertheless, F₃ populations- I-93113 and I-93027 showed high frequency of early plants, which may be selected and included to further agronomic evaluations.

The intermediate similar behavior for flowering date pointed that some of the wild introductions of *A. fatua* had genes for earliness, as well as some of the segregating F₃ populations (I-93113 and I-93027) which showed similar means within the group and differences among cultivated groups and segregating F₂ populations. These results differ from that obtained from Tavares (1991) when evaluated *A. sterilis* introductions and cultivated oat genotypes, where the first showed superiority for flowering date in relation to the cultivated group.

Oat wild races (*A. fatua* and *A. sterilis*) are closely related to the cultivated group and seems to be a potential source of genes helpful to plant breeding. Our results about morpho-physiological traits on wild introductions and natural segregating populations of *A. fatua* x *A. sativa* demonstrated genetic variability within and among the evaluated groups. As a consequence, the maintenance of related wild genotypes is important for conservation and transference of genes of agronomic importance into cultivated germ plasm, assuring genetic diversity in the germ plasms, allowing the breeder to select genotypes with high grain yield and adaptive traits (plant height and flowering date) desirable to conditions of the Southern Brazil.

CONCLUSIONS

1. The groups evaluated result in broad genetic variability within and among groups for both morpho-physiological traits.
2. Wild introductions of *Avena fatua* L. present tall plants and reduced flowering date.
3. The populations I-93027 and I-93113 show genotypic combination of reduced plant height and earliness.

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