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LEAF TYPE AND GRAIN YIELD IN FORAGE PEA

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A three-year trial (2000-2002) was aimed to investigate the grain yield of nine pea genotypes with different leaf type. One (Akatsievydnaya Forma) had acacia (*Aftl*), four (NS-junior, Moravac, Javor and Amino) normal (*AfTl*) and four (Jezero, 4(1993), CD and Primeroy) afila (*afTl*) leaf type. Average plant height (PH), first pod height (FPH), internode number (IN), pod number per plant (PNP), grain number per plant (GNP), plant mass (PM), grain yield per plant (GYP) and per area unit (GYA), harvest index (HI) and thousand grains weight (TGW) were studied. There existed significant differences in all yield components, both between the different leaf type groups and between the genotypes of the same group. The *AfTl* cultivars had the greatest values for PH (75.2 cm), FPH (43.5 cm), IN (18.9), PNP (8.7), GNP (34.2), PM (15.89 g) and GYP (6.97 g). The *afTl* genotypes had the greatest HI (0.56), GYA (2980 t/ha) and TGW (255 g). As for the cultivars, NS-junior was characterized by the greatest values of PH (120.4 cm), FPH (68,6 cm), IN (22.2), PNP (11.3), GNP (42.5) and PM (17.95 g). Javor had the greatest GYP (8.56 g), while the greatest HI was determined in genotype 4(1993) (0,60). The greatest GYA was in Primeroy (4298 kg/ha) and the greatest TGW was measured in Moravac (301 g).

Key words: pea, leaf type, grain yield, acacia, semi-leafless

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INTRODUCTION

Pea (*Pisum sativum* L.), one of the oldest cultivated crops, originates from Europe, northwestern Asia and northern Africa (ZEVEN and ZHUKOVSKY, 1975). Two pea varieties, var. *sativum* and var. *arvense* (L.) Poiret, are used for human consumption, concentrated animal feed, roughage, or green manure (MAXTED and AMBROSE, 2000).

The pea leaf type is controlled by the interaction between two genes: *af* and *tl*. The *af* gene, which is located on chromosome I (http://pisum.bionet.nsc.ru, 1998), was first described by KUJALA (1953). The behavior of the *tl* gene, located on chromosome V (JOHN INNES CENTRE, 1998) and first isolated by SHARMA (1972), was first observed by VILMORIN (1910).

Most pea cultivars that have been developed so far have normal, conventional leaves, which consist of two or three pairs of leaflets and an odd number of tendrils, most often five. In this type of leaves, the *af* and *tl* genes are homozygous and dominant (ĐINOVIĆ, 1984), so the genetic structure of such plants is *AfAf TlTl*. The *af* gene is recessive (*afaf TlTl*) and inhibits the generation of leaflets, resulting in the development of a leaf type consisting only of an odd number of tendrils (ХВОСТОВ, 1975), usually 11 or 13, known as the semi-leafless, or afila, type. The recessive form of the *tl* gene (*AfAf tltl*) causes the leaflet tendrils to transform and produces a leaf type known as the acacia type, which has an odd number of leaflets and no tendrils (МАКАШЕВА, 1973). The progeny of a cross between semi-leafless and acacia pea genotypes will belong to a fourth leaf type, the so-called afila-tendrilled acacia, which has multiple odd-numbered pinnate leaves and a genetic structure of *afaf tltl*. One of the first students of this leaf type, which consists of an odd number of branching tendrils ending in small leaflets, was MARX (1987).

Conventionally-leaved pea cultivars have several unfavorable characteristics: a dense leaf canopy that shadows the lower parts of the plant; a less well-lit crop interior and the resulting reduced photosynthetic activity of the lower leaves; and susceptability to pathogen attacks due to increased moisture under shaded conditions (GOLDMAN and GRITTON, 1992a). Because of all this, research began on agronomic traits of genotypes with different leaf types and their possible uses in agriculture. Semi-leafless genotypes are in principle less susceptible to lodging (SNOAD and GENT, 1976; DAVIES, 1977) but just as capable of transforming the sunlight into dry matter (HEATH and HEBBLETHWAITE, 1985), which is why in a large number of cases they will give yields that are just as high as those of cultivars with conventional leaves (WEHNER and GRITTON, 1981). There have been cases where the grain yield of semi-leafless pea was lower compared with conventional pea, primarily due to a reduced number of pods and fertile nodes (CARDI *et al.*, 1987) or because of inadequate crop density (GONZALES-LAUCK, 1990). The greatest obstacle to improving the characteristics of semi-leafless pea cultivars is their lower initial growth rate relative to conventional pea (PYKE and HEADLEY, 1982). These shortcomings of the semi-lefless pea could be rectified by increasing the stand density and using cultivars with larger seeds, since the initial seed mass and growth rate are positively correlated (HEADLEY and AMBROSE, 1981).

The acacia-type pea plants are most often a result of spontaneous (МАКАШЕВА, 1962) or induced (WELLENSIEK, 1959) mutations. They are characterized by a greater assimilative area and can hence be of importance in green forage production, but they are at the same time more susceptible to lodging due to their inability to find support (ĐINOVIĆ, 1984). The agronomic traits of the afila-tendrilled acacia pea have not been studied yet. It has been accepted that such genotypes have certain advantages (e.g. dry grain yield) over the semi-leafless ones in a thin stand (GOLDMAN and GRITTON, 1992a). In a dense stand, however, this leaf type will not outyield either the conventional or semi-leafless genotypes, although such possibility does exist with genotypes with a longer growing season (GOLDMAN and GRITTON, 1992b).

MATERIALS AND METHODS

A small-plot trial was carried out on a slightly calcareous chernozem at the Rimski Šančevi Experiment Field of the Institute of Field and Vegetable Crops in Novi Sad during 2000-2002. Included in the study were nine genotypes of high-protein spring forage pea from the genetic collection of the Institute's Forage Crops Department, namely one with *Af tl*-type leaves (Акациевидная форма from Moldova), four with *Af Tl*-type leaves (NS-junior, Moravac, Javor created in Novi Sad and Amino from France) and four with *af Tl-type* leaves (Jezero from Novi Sad, 4(1993) from Czech Republic, CD from Denmark and Primeroy from the Netherlands). The cultivar NS-junior, which is intended for both green forage and grain, has an average grain protein content of up to 28% (MIHAILOVIĆ *et al*., 1993), while the intensive cultivars Jezero, Javor (MIHAILOVIĆ *et al*., 2003) and Primeroy have a potential for dry grain yield of up to 5 t/ha.

Because some morphological traits are major components of yield (ХРОСТОВА, 1973), we monitored the average plant height, first pod height, internode number, pod number per plant, grain number per plant, plant mass, grain yield per plant and grain yield per unit area, harvest index, and 1000-grain mass. Our study was also aimed at determining the differences between the morphological and production characteristics of genotypes with the three different leaf types and assessing their potential for successful growing in the agroecological conditions of Serbia and Montenegro. The study results were processed by analysis of variance using the LSD test.

RESULTS AND DISCUSSION

Plant height. - The prevailing production conditions, most importantly precipitation (ĆUPINA, 1993), will cause significant differences in plant height of the same cultivar in different years. In the present study, we found highly significant differences in average plant height between individual cultivars as well as between the *Af Tl* and *af Tl* groups. The greatest plant height was found in the cultivar NS-junior (120. 4 cm) and the smallest in line CD (43.2 cm). The genotype

group with conventional leaves had the greatest average plant height (75.2 cm), while the semi-leafless group had the smallest (50.5 cm) (Table 1).

Table 1. Average values of grain yield components of high-protein spring pea during 2000-2002 according to cultivar

Trait / Genotype	Plant height (cm)	First pod heigh (cm)	Inter-node number	Pod number per plant	Grain number per plant	Plant mass (g)	Grain yield per plant (g)	Harvest index	1000-grain mass (g)
Акациевид-ная форма	69.9	40.8	16.1	8.2	23.3	12.19	5.60	0.46	193
NS-junior	120.4	68.6	22.2	11.3	42.5	17.95	5.76	0.35	153
Moravac	73.5	38.4	18.7	8.6	31.4	16.68	6.93	0.40	301
Javor	5.6	33.6	17.0	8.5	32.5	16.24	8.56	0.53	287
Amino	56.0	33.4	17.7	6.4	30.5	12.70	6.64	0.51	244
Jezero	56.5	37.5	18.1	6.9	26.3	14.08	7.09	0.50	291
4(1993)	51.4	38.2	17.7	6.7	21.6	9.81	5.88	0.60	222
CD	43.2	31.5	17.0	5.3	22.0	12.31	7.28	0.59	299
Primeroy	50.8	40.3	17.8	6.5	24.7	10.30	5.90	0.57	207
LSD 0.05	7.9	4.5	1.8	1.9	9.5	5.22	3.16	0.09	11
0.01	10.5	6.0	2.4	2.5	12.7	6.96	4.21	0.12	15

First pod height. - The cultivar NS-junior had the average first pod height that was significantly higher than in any of the other cultivars (68.6 cm), while the smallest value of this character was recorded in line CD (31.5 cm). Differences in average first pod height between the *Af Tl* (43.5 cm) and *af Tl* (36.9 cm) groups were highly significant statistically (Table 2).

Internode number. - The cultivars with conventional leaves had a significantly higher average number of internodes (18.9) than the genotypes with acacia-like leaves (16.1). There were no significant differences between the *Af Tl* and *af Tl* groups. The highest average internode number was found in NS-junior (22.2) and the lowest in line Акациевидная форма (16.1).

Pod number per plant. - Thanks to its tendency towards prolific branching and a large number of nodes, NS-junior had the largest pod number per plant as well (11.3). There were highly significant statistical differences between its value of this trait and those of the other eight cultivars, among which line CD

had the smallest number of pods per plant CD (5.3) The genotype group with conventional leaves had significantly more pods per plant (8.7) than the semi-leafless one (6.3).

Table 2. Average values of grain yield components of high-protein spring pea during 2000-2002 depending on leaf type

trait / leaf type	Plant height (cm)	First pod height (cm)	Inter-node number	Pod number per plant	Grain number per plant	Plant mass (g)	Grain yield per plant (g)	Harvest index	1000-grain mass (g)
Af tl	69.9	40.8	16.1	8.2	23.3	12.19	5.60	0.46	193
Af Tl	75.2	43.5	18.9	8.7	34.2	15.89	6.97	0.45	244
af Tl	50.5	36.9	17.7	6.3	23.7	11.62	6.54	0.57	255
LSD 0.05	7.9	4.5	1.8	1.9	9.5	5.22	3.16	0.09	11
0.01	10.5	6.0	2.4	2.5	12.7	6.96	4.21	0.12	15

Grain number per plant. - Significant differences in average grain number per plant were found between the cultivar NS-junior (42.5) and most other genotypes, where line 4(1993) had the smallest value (21.6). The *Af Tl* had a significantly higher number of grains per plant (34.2) than the *af Tl* (23.7) group.

Plant mass. - Being a cultivar intended for combined use, NS-junior had the largest plant mass (17.95 g), which was significantly more in statistical terms than the mass measured in line 4(1993) (9.81 g). No significant differences were found between the average plant mass values of the conventionally leaved (15.89 g) and semi-leafless (11.62 g) genotypes.

Grain yield per plant. - The highest grain yield per plant was found in the cultivar Javor (8.56 g) and the lowest in line Акациевидная форма (5.60 g). Statistically significant differences in this trait between either the cultivars or cultivar groups were not observed. The *Af Tl*-type genotypes generally had higher grain yields per plant (6.97 g) than the *af Tl* (6.54 g) and *Af tl* (5.60 g) ones.

Grain yield per unit area. - The cultivar Primeroy produced the largest grain yield per unit area (4,298 kg/ha), while NS-junior had the lowest (1,881 kg/ha). The semi-leafless genotypes had a higher yield per unit area (2,980 kg/ha) than either the conventional (2,217 kg/ha) or acacia-like (2,175 kg/ha) ones.

Harvest index. - As a highly heritable character, the harvest index depends the most on the cultivar's genetic constitution (MIHAILOVIĆ, 1994). Because of their smaller biomass, the *af Tl* genotypes had a significantly larger harvest index (0.57) than the *Af Tl* (0.45) and *Af tl* groups (0.46). The highest harvest index was recorded in line 3(1994) (0.60) and the lowest in NS-junior (0.35).

1000-grain mass. - Highly significant differences in 1000-grain mass were found both among the cultivars and cultivar groups. The largest average 1000-grain mass was found in the cultivar Moravac (301 g), which is near the upper limit of the average value for the whole pea species (SAREP, 1999). The smallest 1000-mass was measured in NS-junior (153 g). The semi-leafless genotypes had a larger 1000-seed mass (255 g) than either the conventional (244 g) or acacia-like ones (193 g).

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Izvod

Cilj trogodišnjeg ogleda (2000-2002) bio je ispitivanje prinosa zrna devet genotipova graška različitog tipa lista. Jedan od njih (Акациевидная форма) imao je bagremasti (*Aftl*), četiri (NS-junior, moravac, javor i amino) normalni (*AfTl*) i četiri (jezero, 4(1993), CD i Primeroy) afila (*afTl*) tip lista. Praćene su prosečna visina biljke (VB), visina prve mahune (VPM), broj internodija (BI), broj mahuna po biljci (BMB), broj zrna po biljci (BZB), masa biljke (MB), prinos zrna po biljci (PZB) i jedinici površine (PZP), žetveni indeks (ŽI) i masa hiljadu zrna (MHZ). Utvrđeno je postojanje značajnih razlika u komponentama prinosa zrna, kako između grupa sa različitim tipom lista, tako i među genotipovima u okviru iste grupe. Sorte *AfTl* genotipa odlikovale su se najvećim vrednostima VB (75,2 cm), VPM (43,5 cm), BI (18,9), BMB (8,7), BZB (34,2), MB (15,89 g) i PZP (6,97 g). Genotipovi *afTl* fenotipa imali su najveći ŽI (0,56), PZP (2980 t/ha) i MHZ (255 g). Sorta NS-junior odlikovala se najvećim vrednostima VB (120,4 cm), VPM (68,6 cm), BI (22,2), BMB (11,3), BZB (42,5) i MB (17,95 g). Najveći PZB (8,56 g) postigla je sorta javor, dok je najveći ŽI određen kod genotipa 4(1993) (0,60). Najveći PZP ostvarila je sorta Primeroy (4298 kg/ha), a najveća MHS izmerena je kod moravca (301 g).

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