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MORPHOPHYSIOLOGICAL CHARACTERS OF TETRAPLOID AMORPHA (*AMORPHA FRUTICOSA* L.) TREES

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The statistical parameters of morpho-physiological characters of tetraploid amorpha vegetative and generative organs were compared to those of diploid amorpha trees. The results are significant for the determination of the nature of polyploidy: auto- or alloploidy, i.e. for the faster selection of the samples for cytological and genetic analyses of amorpha.

Key words: Amorpha fruticosa L., polyploids, genome, morphological characters

INTRODUCTION

Polyploidy was discovered in the early 20th century, when the method of cytological research became more intensively applied. The main discoverers were WINKLER, 1916, who proposed the term polyploidy and WINGE, 1917, who partly explained the essence of polyploidy. The terms autopolyploidy and alloploidy were introduced by KIHARA and ONO, 1926. Polyploids are the organisms with three and more basic, haploid chromosome sets. Almost 40% of all angiosperms are polyploids. The ecological significance of polyploids is high. Compared to the

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related diploids, they are more frequent in pioneer communities of trees and shrubs affected by ± stress factors (frost, drought, extreme temperature, etc.).

OBJECT AND METHOD

The rare tetraploid amorpha (*Amorpha fruticosa* L.) trees were recorded in the stationary stands at the flooded sites of Ada Ciganlija (Figure 1), i.e. the sites of white willow (Salicetum albae, s.l.), black poplar (Populetum nigrae s.l.), white poplar (Populetum albae s.l.) and pedunculate oak and narrow-leaved ash (Querceto-Fraxinetum s.l.). The caryological-systematic characters of amorpha were identified by TSCHENKOV, 1930; WANNSCHER, 1934; TURNER, 1956; BERGER *et al.*, 1958; HINDAKOVA, 1967, etc. In the aim of directed selection of samples for further genetic study, i.e. analyses, we carried out the comparative morpho-physiological analysis of tetraploid and diploid shrubs. The quantitative parameters of the leaves, inflorescences and fruits were statistically processed. The justified differences were determined by Student's t-test.

Figure 1. - Pure community (sinuzija) of amorpha at the white poplar (Populetum albae s.l.) site on Ada Ciganlija, near Belgrade

THE RESULTS OF MORPHOPHYSIOLOGICAL ANALYSES AND DISCUSSION

The first visible effect of tetraploidy is the enlargement of leaves, inflorescences and fruits compared to diploid trees (Figures 2, 3, 4 and 5). The comparative morphological analysis shows the statistically justified differences in the compound leaf length and width, length, width, area and number of leaflets, as well as the number of ether drops (glands) per cm² (Table 1). Statistically justified differences were recorded for all seven study characters of the leaves (t=2.52 to 21.46). Statistically justified differences were recorded for two of the three characters of inflorescences i.e. inflorescence length (t=10.66 to 15.75) and number of fruits in inflorescences (t=3.92 to 6.47), whilst the inflorescence width ± coincides with the diploid inflorescences (Table 2). Statistically justified differences characterise the one-seed pods, i.e. length (t=6.52 to 15.11) and width (t=2.81 to 5.26). Oppositely, the parameters of germination percentage are considerably lower than those of diploid trees (Table 3).

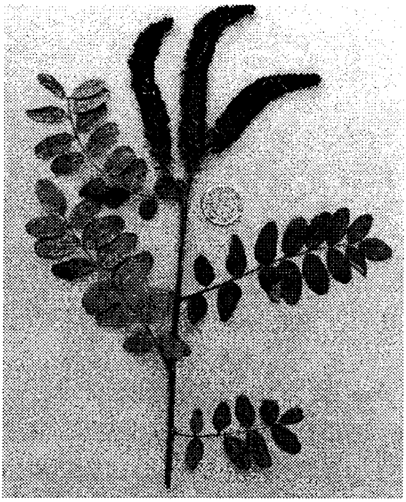

Fig. 2. - A twig with terminal inflorescences in the optimal phase of amorpha (*Amorpha fruticosa* var. fruticosa) flowering

Fig. 3. - A twig with terminal inflorescences of amorpha tetraploid shrub

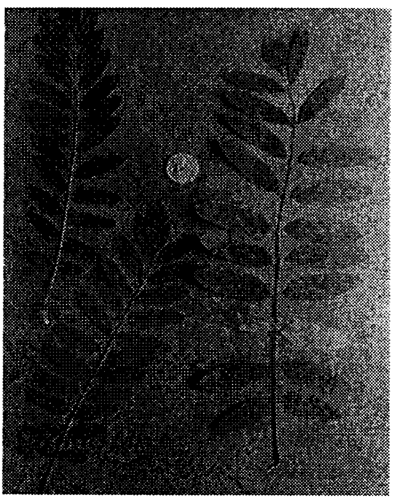

Fig. 4. - Compared leaves of diploid - var. fruticosa (left) and tetraploid amorpha trees

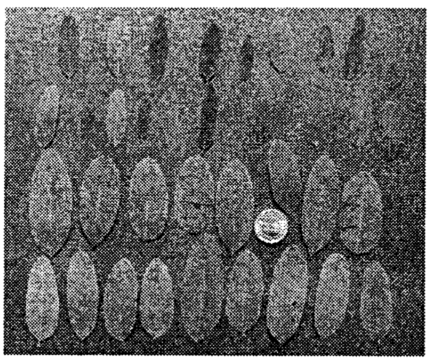

Fig. 5. - Variability of leaflets of the compound leaf of the diploid (up) and tetraploid (down) amorpha

Table 1. - Comparative characters of the leaves of diploid (2n) and tetraploid (4n) amorpha (Amorpha fruticosa L.) shrubs

Trees	2n: genotypes $\xi \pm S\xi$	4n: genotypes $\xi \pm S\xi$	t – values
	Length of compound leaf in cm		
1	23.10 ± 0.32	33.40 ± 0.58	15.61
2	21.17 ± 0.44	32.63 ± 0.42	18.79
3	21.83 ± 0.36	31.00 ± 0.38	18.40
4	20.84 ± 0.30	31.27 ± 0.53	17.10
5	22.57 ± 0.36	32.23 ± 0.43	17.25
	Width of compound leaf in cm		
1	8.07 ± 0.21	10.13 ± 0.14	8.58
2	8.83 ± 0.29	10.22 ± 0.09	4.63
3	8.50 ± 0.29	10.87 ± 0.18	7.18
4	8.61 ± 0.27	9.70 ± 0.20	3.30
5	7.73 ± 0.07	10.27 ± 0.18	7.94
	Number of leaflets in the compound leaf		
1	23.27 ± 0.52	25.90 ± 0.51	3.60
2	24.20 ± 0.55	26.62 ± 0.79	2.52
3	22.50 ± 0.53	27.67 ± 0.47	7.14
4	20.17 ± 0.53	26.40 ± 0.51	8.53
5	21.97 ± 0.46	24.30 ± 0.42	3.76
	Length of leaflets in mm		
1	3.73 ± 0.08	5.40 ± 0.35	4.77
2	4.13 ± 0.10	5.70 ± 0.40	3.92
3	3.73 ± 0.26	6.13 ± 0.26	6.86
4	3.88 ± 0.08	5.77 ± 0.21	8.59
5	3.77 ± 0.07	5.63 ± 0.18	9.79
	Width of leaflets in mm		
1	1.37 ± 0.04	2.15 ± 0.04	13.00
2	1.57 ± 0.03	2.23 ± 0.02	22.00
3	1.48 ± 0.05	2.28 ± 0.04	13.33
4	1.70 ± 0.05	2.29 ± 0.03	9.83
5	1.48 ± 0.05	2.19 ± 0.03	11.83
	Area of leaflets in cm^2		
1	3.35 ± 0.07	7.50 ± 0.24	11.60
2	3.18 ± 0.08	6.40 ± 0.13	21.46
3	3.83 ± 0.12	6.50 ± 0.35	7.22
4	3.45 ± 0.14	6.87 ± 0.19	13.83
5	3.92 ± 0.14	7.13 ± 0.29	9.84
	Number of glands per cm^2		
1	40.00 ± 1.98	24.00 ± 1.59	6.25
2	38.00 ± 1.83	26.00 ± 0.99	5.77
3	45.33 ± 2.05	20.60 ± 2.34	7.93
4	34.00 ± 2.13	23.70 ± 0.88	4.44
5	42.67 ± 2.34	24.70 ± 1.77	6.13

Table 2. - Comparative characters of inflorescences and one-seed pods of diploid (2n) and tetraploid (4n) amorpha shrubs

Trees	2n: genotypes $\xi \pm S\xi$	4n: genotypes $\xi \pm S\xi$	t – values
	Length of inflorescences in cm		
1	14.38 ± 0.51	24.62 ± 0.40	15.75
2	14.99 ± 0.49	23.00 ± 0.60	15.59
3	15.03 ± 0.57	22.88 ± 0.37	10.66
4	14.88 ± 0.42	24.11 ± 0.52	13.38
5	14.20 ± 0.38	23.60 ± 0.43	16.49
	Width of inflorescences in cm		
1	20.32 ± 0.82	21.10 ± 0.27	0.91
2	21.10 ± 1.10	22.25 ± 0.41	0.95
3	20.88 ± 1.12	22.73 ± 0.36	1.57
4	22.03 ± 0.99	23.62 ± 0.39	1.50
5	21.83 ± 1.33	24.11 ± 0.28	1.31
	Number of fruits in the inflorescence		
1	163.12 ± 2.09	29.60 ± 4.71	5.72
2	148.63 ± 3.15	266.02 ± 3.12	3.92
3	159.02 ± 3.07	286.44 ± 3.73	5.68
4	159.82 ± 2.62	291.23 ± 4.11	6.47
5	162.72 ± 1.86	281.47 ± 3.28	4.97
	Length of one-seed pod in mm		
1	8.33 ± 0.06	9.36 ± 0.13	7.20
2	8.02 ± 0.07	10.12 ± 0.12	15.11
3	9.03 ± 0.09	10.88 ± 0.14	11.14
4	10.10 ± 0.07	11.23 ± 0.15	6.85
5	9.99 ± 0.11	11.00 ± 0.11	6.52
	Width of pod in mm		
1	3.02 ± 0.03	2.81 ± 0.06	3.13
2	3.43 ± 0.03	3.74 ± 0.08	3.64
3	3.51 ± 0.08	3.20 ± 0.17	2.81
4	3.10 ± 0.12	3.92 ± 0.10	5.26
5	2.91 ± 0.05	3.21 ± 0.07	3.49

Table 3. - Comparative results of the laboratory analysis of seed - pod germinability after seed soaking in water for 8 days

Parameters of germination (%)	2n: genotypes				4n: genotypes			
	1	2	3	4	1	2	3	4
Germination percentage	91	94	95	90	40	42	54	46
Germination energy	89	90	86	79	20	26	31	29

The effects of amorpha tetraploidy are shown by the gigantic leaves (similar to black locust), especially the lengths of inflorescences and the number of fruits in inflorescences. Tetraploid trees have a considerably greater number of pods. The larger sizes of the vegetative and reproductive organs by all means increase the tetraploid shrub competitiveness and adaptation. Because of the notably lowered parameters of seed germination percentage, it is evident that tetraploid trees are not immediately suitable for practical cultivation. Tetraploid trees are only interesting as the transitional trees in the directed selection (initial material for selection), as during their reproduction in the successive generations they acquire better properties for the selection of genotypes. The occurrence of tetraploid individuals is a special form of mutation, the so-called genome mutation (TUCOVIĆ, 1990). Thanks to their gigantism, the analysed amorpha tetraploid individuals are probably better adapted to the colonisation of the flooded forest sites than the diploid individuals. They readily absorb the new recombinations and mutations. Therefore, polyploidy is an efficient protection system, which prevents the effect of natural selection on individual genes and supports the maintenance of the individuals phenotype stability. The capacity of colonisation of the new ± unpopulated sites, is probably the main cause of their successful invasion of various regions of the secondary range of the species, whether they be of ancestral or more recent origin.

CONCLUSIONS

The first visible effects of amorpha tetraploidy are the enlarged leaves, inflorescences and fruits (pods). Evidently, it is not yet possible to perform a more detailed classification into auto- or alloploidy, as the identified differences cannot serve as the reliable criterion without the caryogram and idiogram at the level of the species. A detailed analysis of fertility requires larger-scale cytogenetic, physiological, cytosystematic and bio-geographic study. It was detected long ago that the frequency of plant polyploidy correlates with latitude (Table 4). The percentage of plant polyploidy increases going from the low latitudes towards the high latitudes. The rare incidence of polyploidy intra species in our country emphasises the need of precise assessment of forest tree and shrub polyploidy frequency. Still, to it is very difficult to make a precise assessment of the frequency of polyploidy in amorpha stands. The percentage of amorpha polyploidy is certainly affected by its life form, the site latitude and altitude, ecological factors, regeneration system, and the effect of genotype.

Table 4. - Percentage of polyploid species of vascular plants in different regions, after Ayala and Kiger, 1984

Region	Latitude	Polyploid %
Sicily	37	37
Hungary	46 - 49	47
Denmark	54 - 58	53
England	50 - 61	57
Sweden	55 - 69	56
Norway	58 - 71	58
Finland	60 - 70	57
Island	63 - 66	64
South Greenland	60 - 71	72

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MORFOFIZIOLOŠKE OSOBINE STABALA TETRAPLOIDNOG BAGRENCA (*AMORPHA FRUTICOSA* L.)

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Izvod

Poliploidi su organizmi sa tri ili više osnovnih, haploidnih hromozomskih garnitura. Skoro 40% skrivenosemenica su poliploidi. Ekološki značaj poliploidije je veliki. U poređenju sa srodnim diploidima oni se češće sreću u pionirskim zajednicama drveća i žbunja na koje deluju ± stresni faktori (mraz, suša, ekstremne temperature i sl.). Objekat istraživanja su retka tetraploidna stabla na šumskim plavnim zajednicama bagrenca. Kariološko-sistematske odlike žbunova tetraploidne amorfe evidentirane su još od TSCHENKOVA, 1930; WANNSCHERA, 1934; TURNERA, 1956; BERGER *et al.*, 1958; HINDAKOVA, 1967, i drugih. Osnovni metod obavljene analize je uporedno morfofiziološka analiza tetraploidnih i kontrolnih (diploidnih) stabala vrste.

Prvi uočljivi efekti tetraploidije ogledaju se u uvećanju razmera listova, cvasti i plodova. Kao rezultat tetraploidije ispoljavaju se znači gigantizma, izraženog u uvećanju mernih osobina, kao i u broju cvetova i plodova u cvastima. Uvećanje kvantitativnih svojstava obezbeđuje adaptivnost žbunova, usled čega su analizirana stabla podesan materijal za delovanje prirodne i usmerene selekcije; očigledno je da analizirana stabla nisu odmah pogodna za praktično gajenje. Tetraploidi predstavljaju isključivi interes kao prelazna etapa u usmerenoj selekciji, s obzirom da se pri semenom razmnožavanju stiču bolje mogućnosti za odabiranje najboljih genotipova. Pojava tetraploidnih individua bagrenca je poseban vid mutacija tzv. mutacija genoma (TUCOVIĆ, 1990). Poliploidi su, najverovatnije, bolje prilagođeni ka kolonizaciji šumskih staništa od strane korovskih vrsta, usled izražene uniformnosti. Oni kao sunđer "upijaju" nove rekombinacije i mutacije. Poliploidija, usled toga, predstavlja efikasan zaštitni sistem, koji sprečava delovanje prirodne selekcije na pojedine gene i pogoduje fenotipskoj uniformnosti. Sposobnost polopoida ka kolonizaciji nenaseljenih staništa ili novootkrivenih staništa, verovatno je osnovni uzrok, uspešnog širenja bagrenca u raznim područjima sekundarnog areala vrste, nezavisno od toga, bili oni drevnog ili novijeg porekla.

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