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QUALITY AND DEVELOPMENT OF CONTAINERIZED SEEDLINGS AND STANDS OF AUSTRIAN BLACK PINE (*PINUS NIGRA* ARN.) IN THE REPUBLIC OF MACEDONIA (FYROM)

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Abstract

In this paper features of container “Paperpot”, “Yucosad”, “Pirosad” and bare root seedlings, used in afforestation in the R. of Macedonia, are presented. Morphometrical features of seedlings were measured and statistically compared. A further development of Austrian black pine trees in stands and in experimental fields, raised from container and bare root seedlings in different ecological conditions was investigated. Height and diameter of trees were measured, and their vitality was estimated. Container type and its volume do not directly influence the seedlings quality. All investigated container seedlings have more or less satisfying features, independently on container. Survival, development and vitality of young stands depends more on site conditions and planting techniques; the influence of container type is not expressive. Survival and vitality of younger stands is quite poor. Trees in older stands develop more or less normally, influenced mostly by site conditions. There is not crucial influence of container type on development and vitality of stands recorded.

Key words: Austrian black pine, bare root seedlings, container seedlings, growth parameters, stands.

Introduction

In the Republic of Macedonia, ca. 20 % of reforestation and specially afforestation, has been executed with container seedlings. Since 1974, container “Paperpot” has been used, while a domestic hard-plastic container “Yucosad” was developed few years later and is widely used ever since. Other containers (“Plantagrah”, “Makosad”, “Pirosad” etc.) are rarely used. The development of stands raised by “Yucosad” seedlings has been under suspicion because of root deformation. Consequently, poor development, and finally dying of “Yucosad” Austrian black pine stands, at age approx. 6–8 years, has been prognosticated (Popovski 1985).

In Macedonia investigations of container seedlings were executed by Popovski (1986), Kolevska (1995), Kolevska et al. (2006), and development of Austrian black pine stands by Kolevska (1995), Trajkov et al. (2002). Container seedling features and development of stands raised by container seedling worldwide were investigated by many researchers (Van Eerden and Arnott 1974, Lokvenc 1985, Scarrath 1991, Jones et. al. 2002, etc).

The aim of this investigation is to establish whether the container seedlings influence the growth and vitality of trees. For this purpose seedlings of Austrian black pine produced in containers "Paperpot", "Yucosad" and "Pirosad" and as bare root, were analyzed. The further development of trees of respective seedling types, in stands and experimental fields, with different age and from various ecological conditions in the R. of Macedonia, was analyzed.

Materials and Objects

There were analyzed 1+0 Austrian black pine seedlings, produced in containers "Paperpot" (FH 508, vol. 120 cm^3), "Yucosad" (hard-plastic, bullet-shape, h=10cm, upper d=3.8 cm, volume=70 cm^3) and "Pirosad" (hard-plastic cylinder-shape, with a plastic cone-shape insert in the lower part of the container for better distribution of the roots, h=12 cm, d=5 cm, volume ca. 160 cm^3). As control, 1+0 bare root seedlings were analyzed. There were analyzed 30 seedlings in 4 replications, i.e. total of 120 seedlings of each seedling type.

The investigation of trees was executed both in stands, planted during regular afforestation activities of the forest operative, and in experimental fields.

Trees in 15 stands from different localities in Macedonia were analyzed. Trees (stands) originated from Paperpot, Yucosad and bare root seedling stocks. Stands develop in different ecological conditions: altitude: 250–1300 m, soil: Eutric Cambisols, Distric Cambisols, Alluvial and Rendzinas. Soil preparation: generally by opening a furrow; planting technique: into a notch or a small hole, by various planting tools.

Apart from these 15 stands, development of container (Paperpot, Yucosad, Pirosad) and bare root trees was analyzed in 4 experimental fields (A, B, C and D). Within each experimental field, container and bare root seedlings were planted by the same planting technique in the same ecological conditions.

Total of 19 stands and experimental fields of age 4–19 years were analyzed. On each stand, i.e. experimental field, 11–30 trees, i.e. a total number of 677 trees were measured and analyzed.

Methods

The following parameters of seedlings were measured: height of shoot (mm); No of lateral buds, root collar diameter (mm) and weight of shoot and roots in absolute dry condition (g).

The following parameters of trees were measured: height of shoot (cm), root collar and stem diameter at 1.3 m (cm). The annual height and diameter increment were calculated. A survival, vitality and stability of trees were estimated. Statistical analyses were executed by SPSS program; ANOVA and t-test were used to compare the means.

Abbreviations used in this paper have the following meaning: PP=Paperpot; YS=Yucosad, PS=Pirosad, BR=Bare root; H=height, AHI=annual height increment, RCD=root collar diameter; $D_{1.3\,m}$=diameter on 1.3 m; ADI=annual diameter increment; WADC=weight in absolute dry condition; N=number of analyzed trees; X=mean; SD=standard deviation; vitality: 1=poor, 2=medium, 3=good; *=statistical significance ($p<0.05$).

Results and Discussion

1. Seedlings 1/0

Parameters of 1+0 seedlings are presented in Table 1. Statistical significance of the means is tested for H and RCD. Compared to BR seedlings as control, only PP seedlings are statistically higher. BR seedlings have bigger RCD than all other seedlings types.

2. Trees in stands and in experimental fields

Results of the investigation of the trees are exposed summarily, both for stands and experimental fields, separately for each seedling stock type, in Tables 2–5. Results are presented starting from youngest trees. Since part of the investigation was executed in 4 experimental fields, where the technique of establishing each experimental field was the same and the trees develop in the same ecological conditions, statistical testing of means is executed. For this purpose, morphological features only for the trees from experimental fields are repeated and results of statistical testing are presented in Tables 6–9.

Results presented in Tables 2–5 show that trees of all seedling type origin develop more or less normally, i.e. according to the age and ecological conditions of the stand (experimental field). Young trees have generally poor vitality, while older trees show good one.

2.1. “Pirosad”

Trees in two 4-year-old experimental fields were investigated. Height of shoots and RCD and resp. increments do not vary in wide range. Trees have medium vitality (Table 2).

2.2. “Paperpot”

Results of investigating trees from 7 stands and 4 experimental fields are presented in Table 3. The less stem height

Table 1. Basic morphometrical features of the seedlings.

Seedling type	H, mm		RCD, mm		H:RCD, mm:mm	No of buds		WADC, g				
								shoot		roots		ratio
	X	SD	X	SD		X	SD	X	SD	X	SD	
BR	74.9	1.20	2.53	0.39	32	3.6	1.2	–		–		–
PP	97.7*	1.63	2.22*	0.49	44	1.6	1.5	0.47	0.12	0.25	0.09	1.88
YS	75.2	1.18	2.11*	0.28	36	3.2	1.0	0.42	0.11	0.25	0.10	1.68
PS	84.5	1.79	2.13*	0.30	40	3.6	1.4	0.58	0.13	0.38	0.13	1.53

Table 2. Biometrical features of the trees of "Pirosad" seedlings origin.

Exp. field	Alti-tude, m	Age, years	N	H, cm			RCD, cm			$D_{1.3\ m}$, cm		Vitality
				X	SD	aver. AHI	X	SD	aver. ADI	X	SD	
A	250	4	11	36.8	10.0	9.2	0.8	0.2	0.2	-	-	2
B	500	4	30	39.7	6.9	9.9	0.9	0.2	0.2	-	-	2

of 4-year-old trees is 34.4 cm, while 14-year-old trees reach 323.2 cm. RCD increases from 0.8 cm to 10.8 cm by 4, resp. 14-year-old trees. The AHI varies from 8.6 cm to 26.8 cm, and the ADI from 0.2 cm to 0.9 cm.

2.3. "Yucosad"

Trees in 5 stands and 4 experimental fields, 4–17 years of age, were analyzed (Table 4). The shoot height varies from 27.9 cm (4-year-old trees) to 402.9 cm (17-year-old). RCD increases from 0.6 cm to 11.5 cm (4, respectively 17-year-old trees). The AHI varies from 7.0 cm to 25.6 cm and the ADI 0.2 cm to 1.0 cm.

2.4. "Bare root"

Trees in 3 stands and 4 experimental fields 4–19 years of age, were investi-

Table 3. Biometrical features of the trees of "Paperpot" seedlings origin.

Exp. field	Alti–tude, m	Age, years	N	H, cm			RCD, cm			$D_{1.3\ m}$, cm		Vitality
				X	SD	aver. AHI	X	SD	aver. ADI	X	SD	
A	250	4	30	34.4	7.9	8.6	0.8	0.1	0.2	–	–	1
B	500	4	30	44.6	9.5	11.2	0.9	0.2	0.2	–	–	1
	400	5	30	49.9	12.8	10.0	1.3	0.4	0.3	–	–	2
	325	10	20	132.2	14.3	13.2	6.2	0.9	0.6	–	–	2
C	1300	10	20	206.7	34.6	20.6	7.8	1.6	0.8	3.5	2.2	3
D	450	11	20	277.9	46.4	25.3	9.5	1.7	0.9	4.4	1.3	3
	300	12	30	204.6	42.2	17.1	6.6	0.8	0.5	1.9	0.5	2
	630	13	17	205.8	29.0	15.8	7.9	1.0	0.6	2.9	1.0	2
	615	13	19	258.6	32.3	19.9	8.0	1.1	0.6	3.7	0.7	2
	600	13	17	348.5	38.4	26.8	10.4	1.6	0.8	6.0	0.8	3
	300	14	20	323.2	29.5	23.1	10.8	1.8	0.8	6.7	1.0	3

Table 4. Biometrical features of the trees of "Yucosad" seedlings origin.

Exp. field	Alti-tude, m	Age, years	N	H, cm			RCD, cm			$D_{1.3\ m}$, cm		Vitality
				X	SD	aver. AHI	X	SD	aver. ADI	X	SD	
A	250	4	11	34.5	7.9	8.6	0.8	0.1	0.2	-	-	1
B	500	4	30	34.7	6.9	8.6	0.8	0.0	0.2	-	-	1
	400	4	20	27.9	6.4	7.0	0.6	0.2	0.2	-	-	2
	400	5	30	55.0	12.2	11.0	1.4	0.3	0.3	-	-	2
	700	8	30	146.1	17.0	18.3	7.7	1.2	1.0	1.8	0.4	2
C	1300	10	20	230.6	37.0	23.1	9.0	1.6	0.9	3.9	1.2	3
D	450	11	17	281.1	42.2	25.6	9.8	1.3	0.9	4.7	1.2	3
	300	16	30	351.7	33.3	22.0	11.3	1.1	0.7	7.0	0.9	3
	420	17	29	402.9	40.7	23.7	11.5	1.4	0.7	7.3	1.0	3

gated (Table 5). The shoot height varies from 38.3 cm (4-year-old trees) to 428.6 cm (19-year-old). RCD increases from 0.8 cm to 12.8 cm by 4, resp. 19-year-old trees. The AHI varies from 7.7 cm to 23.1 cm, and the ADI from 0.2 cm to 0.9 cm.

2.5. Experimental fields

Four of the investigated stands were established as experimental fields A, B, C and D. In Tables 6–9 a repetition of the features of trees from the experimental fields (from Tables 2–5) is presented, separately

Table 5. Biometrical features of the trees of "Bare root" seedlings origin.

Exp. field	Alti-tude, m	Age, years	N	H, cm			RCD, cm			$D_{1.3\ m}$, cm		Vitality
				X	SD	aver. AHI	X	SD	aver. ADI	X	SD	
A	250	4	11	42.7	9.3	8.5	0.8	0.2	0.2	–	–	1
B	500	4	30	38.3	8.7	7.7	0.8	0.3	0.2	–	–	1
	1000	9	30	121.8	26.9	13.5	6.2	1.4	0.7	–	–	2
C	1300	10	17	249.3	46.8	22.7	9.6	2.1	0.9	4.5	1.6	2
D	450	11	18	277.1	40.8	23.1	9.6	1.5	0.8	4.5	1.3	3
	420	17	30	317.0	27.1	18.6	12.5	1.7	0.7	6.5	1.0	3
	380	19	30	428.6	48.5	22.6	12.8	1.8	0.7	7.9	1.3	3

Table 6. Biometrical features of the trees in experimental field A.

Exper. field	Seedl. type	Age, years	N	H, cm			RCD, mm			$D_{1.3\ m}$		Vitality	Survi-val %
				X	SD	aver. AHI	X	SD	aver. ADI	X	SD		
A	BR	4	30	38.3	8.7	7.7	0.8	0.3	0.2	–	–	1	20
A	PS	4	30	39.7	6.9	9.9	0.9*	0.2	0.2	–	–	2	40
A	PP	4	30	44.6*	9.5	11.2	0.9*	0.2	0.2	–	–	1	30
A	YS	4	30	34.7	6.9	8.6	0.8	0.0	0.2	–	–	1	30

for each experimental field, together with the results of comparative analyses of statistical testing (with BR trees as control).

Experimental field A (Table 6) represents a young stand, where ecological conditions are far from favorable for Austrian black pine (250 m a.s.l.) Best results show PP and PS trees, while YS trees have worst features. PP seedlings are statistically higher and thicker than control (BR). Vitality of all seedling types is poor to medium, and survival range is low.

Quite similar situation is recorded in experimental field B (Table 7), which also represents young stand in less favorable ecological conditions (500 m a.s.l.) Best results manifest BR trees, while container stock types have quite similar features. Vitality of all seedling types is poor to medium. Survival range is low in all seedling types.

Experimental field C (Table 8) is raised in very favorable ecological conditions (1300 m a.s.l.) BR trees have statistically better features compared to trees with container origin. Vitality of all trees is good. Survival range is high in all seedling types.

Experimental field D (Table 9) is raised in less favorable ecological conditions (450 m a.s.l.), however vitality of all trees is good and survival range is high. Features of trees of all seedlings stock types are very close, without statistically significant differences.

From this investigation arises that container type, i.e. its volume, does not directly influence the seedlings quality. Quite big differences between container vol-

Table 7. Biometrical features of the trees in experimental field B.

Exper. field	Seedl. type	Age, years	N	H, cm			RCD, mm			$D_{1.3\ m}$		Vitality	Survi-val %
				X	SD	aver. AHI	X	SD	aver. ADI	X	SD		
B	BR	4	11	42.7	9.3	8.5	0.8	0.2	0.2	–	–	1	20
B	PS	4	11	36.8	10.0	9.2	0.8	0.2	0.2	–	–	2	40
B	PP	4	30	34.4*	7.9	8.6	0.8	0.1	0.2	–	–	1	30
B	YS	4	11	34.5*	7.9	8.6	0.8	0.1	0.2	–	–	1	30

Table 8. Biometrical features of the trees in experimental field C.

Exper. field	Seedl. type	Age, years	N	H, cm			RCD, mm			$D_{1.3\ m}$		Vitality	Survival %
				X	SD	aver. AHI	X	SD	aver. ADI	X	SD		
C	BR	10	17	249.3	46.8	22.7	9.6	2.1	0.9	4.5	1.6	3	80
C	PP	10	20	206.7*	34.6	20.6	7.8*	1.6	0.8	3.5*	2.2	3	90
C	YS	10	20	230.6*	37.0	23.1	9.0	1.6	0.9	3.9*	1.2	3	85

Table 9. Biometrical features of the trees in experimental field D.

Exper. field	Seedl. type	Age, years	N	H, cm			RCD, mm			$D_{1.3\ m}$		Vitality	Survival %
				X	SD	aver. AHI	X	SD	aver. ADI	X	SD		
D	BR	11	18	277.1	40.8	23.1	9.6	1.5	0.8	4.5	1.3	3	90
D	PP	11	20	277.9	46.4	25.3	9.5	1.7	0.9	4.4	1.3	3	95
D	YS	11	17	281.1	42.2	25.6	9.8	1.3	0.9	4.7	1.2	3	95

ume (70, 120 resp. 160 cm^3) are not followed by respective differences in seedling features (PP seedlings from 120 cm^3 are statistically higher than PS seedlings from 160 cm^3 volume container). Many researchers, who investigated seedling development in various containers, have come to similar conclusions (Petrovic 1991, Lokvenc 1980, Popovski 1986). However, more important than initial seedlings features is their survival and growth on new site. Investigations on stands established with container seedlings have been executed worldwide (Thompson 2001, Van Eerden and Arnott 1974, Jones et al. 2002, Scarrath 1991), which testify about great importance of this issue. Volná and Mauer 1983, Stilinovic et al. 1980, Lokvenc 1985, Šmit et al. 1985, Kolevska 1995, etc. established that development of trees depends on number of factors, and among them container type has various influence. However, vitality and development of trees from container seedlings reflect their complex condition, specially their non-visible part – the root system (according to Lokvenc, 1980, 1985, Volná and Mauer (1983) etc.) They established that one of the factors which can significantly influence the development of the "container stands" is roots deformations, which emerge during the growth of seedlings in the container and/or during and after transplantation.

Comparison of features of young trees (age 4–5 years) in this investigation, with the results of Austrian black pine stands investigations at the same age, container types and similar ecological conditions (Popovski et al. 1983, Stilinovic et al. 1986, Kitic and Vilotic 1985 etc.) does not show considerable differences. Most of other investigators emphasize on the mutual influence of site factors and planting procedures on the future development of stands, and they do not consider container type as a crucial factor. Survival and development of young container trees depends more on site conditions and planting techniques, because of relatively small dimension of the shoot and root ball (possible damages of weeds, danger of drought, root deformities). Especially dry sites, unfavorable soil conditions, poor site preparation and bad planting can cause serious problems in stand development. In such conditions, regeneration of roots is poor, which causes worse seedlings survival and vitality. This is the case in our investigation, where all young stands, raised on dry sites, manifest poor vitality and survival (20–40 %) and numerous root deformities. Even the Pirosad seedlings with the biggest volume of the container have quite a low survival range (ca. 35 %). This proves that even container seedlings can face a biological shock after transplanting, similarly to bare root seedlings.

According to this investigation, the influence of container type on development of trees in older stands becomes even less significant. All analyzed stands develop more or less normally, conditionally to planting techniques and site conditions. Vitality of older stands is medium to good, and there is no crucial influence of specific container type recorded. The experimental fields confirm such statement: bigger differences between trees of different origin were recorded on experimental field C, while very small ones on field D.

Conclusions

Best parameters have "Pirosad" and "Paperpot" seedlings. The other seedling stock types have satisfactory quality parameters.

Growth and vitality of trees, raised from different seedling types, by various planting techniques and developing in different ecological conditions, do not depend primarily on seedling type.

Young container stands have faced biological shock similarly to bare root seedlings. Development of stands is influenced mostly by climatic conditions in the first years after transplanting, site conditions, quality of planting, etc. Older stands, raised both from container and bare root seedlings, develop well.

All investigated container type seedlings, i.e. "Paperpot", "Yucosad" or "Pirosad", with a prerequisite of expert, consistent, timely and high-quality executing of all separate steps in seedling production and planting process will contribute to development of productive, stable and healthy stands.

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