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GROWTH AND CROPPING OF FOUR PLUM CULTIVARS ON DIFFERENT ROOTSTOCKS IN SOUTH WESTERN POLAND

ABSTRACT. The experiment was established at a spacing of 4 x 2 m. Plum cultivars were grafted on the 'Wangenheim Prune' seedlings and three vegetative rootstocks: 'Pixy', 'GF 655/2' and 'St. Julien A'. Until the seventh year after planting, the growth, yield, fruit quality and survival were affected by the cultivar and rootstock. 'Pixy' appeared very frost sensitive. After the severe winter of 1996/97 some trees on this rootstock died. 'Čačanska Rana' cultivar was the most productive on 'Wangenheim Prune' seedlings. Total yields per tree from 1996 to 2001 were the highest for 'Empress' and 'Oneida' trees on 'GF 655/2'. 'Pixy' and 'Wangenheim Prune' rootstocks reduced a vegetative growth of plum cultivars in comparison to 'GF 655/2'. Type of rootstock had no influence on fruit weight. Production of root suckers was the most prolific on 'GF 655/2'.

Key words: plum, rootstocks, cultivar, growth, yield, fruit quality

INTRODUCTION. Research works concerning new plum cultivars have been conducted in different parts of Poland for several years (Lipecki et al., 1994; Sitarek et al., 1995; Łysiak, 1996; Sosna et al., 1998). Recently, a large choice of plum varieties appeared, which are highly tolerant to plum pox, highly productive, very early start to bear and have attractive, large and tasty fruit. Greater chances for a profitable sale are given by cultivars with very early ripening fruits, such as 'Herman', 'Čačanska Rana' and 'Sanctus Hubertus', and those late ripening, of which fruits can be stored for even 2-3 weeks, for example 'Bluefre', 'President' and 'Oneida'.

Modern fruit growing does not mean only a cultivar. Very important are rootstocks suitable for a high density plum orchard. Knowledge about the usefulness of different types of rootstocks for different varieties is still very limited. They can affect not only the vegetative growth but also yield and fruit quality. The most popular vigorous rootstock in plum orchards (not only in Poland) is Myrobalan seedling (*Prunus cerasifera)*. Unfortunately, it is not the best, especially for varieties with a strong vegetative growth (Tehrani and Leuty, 1987; Barroso, 1998; Grzyb et al., 1998; Kosina et al., 2000). Besides of *Prunus cerasifera,* also 'Wangenheim Prune' seedlings are important in Polish nursery production (Czynczyk, 1993). In comparison to Myrobalan seedlings, plum trees grafted on 'Wangenheim Prune' semi-dwarf rootstock grow weaker and are more productive (Rozpara and Grzyb, 1998). At present, a very important role in the intensification of plum orchards have vegetatively propagated rootstocks, such as 'Pixy', 'GF 655/2' and 'St. Julien A'. Their suitability for cultivation is evaluated in many countries in Europe and North America (Riesen and Husistein, 1992; Webster and Wertheim, 1993; Ystaas et al., 1994; Boyhan et al., 1998; Grzyb et al., 1998; Embree et al., 1999). Planting plum trees grafted on dwarf or semi-dwarf rootstocks enables an increase of tree number in a row and leads to a higher yield per unit area with a decrease of tree growth vigour (Botu et al., 1998; Kosina et al., 2000).

The aim of the present study was the estimation of the production value of several plum cultivars on different rootstocks in the Lower Silesia region.

MATERIAL AND METHODS. The experiment was established at the spring of 1995 at the Fruit Experimental Station, Samotwór near Wrocław. One-year-old trees of four plum cultivars – 'Čačanska Rana', 'Čačanska Najbolja', 'Empress' and 'Oneida' budded on 'Wangenheim Prune' seedlings and three vegetative rootstocks such as 'Pixy', 'GF 655/2' and 'St. Julien A' were planted on pseudopodsolic soil overlaying boulder clay. Trees were spaced in rows at 2 m whereas the distance between rows equalled 4 m (1250 trees per hectare). Until the third year after planting, plum tree canopies were formed as a spindle with minimum pruning and shoots maximally bending down by using concrete weights. Since the fourth year, trees were annually pruned soon after blooming. The experiment was carried out in a randomised block design, in 4 replications with 4 trees per plot. Since the first year, there was a herbicide fallow in the rows and sward between them. Chemical protection was carried out according to the current recommendation of the Orchard Protection Programme. Till the seventh year after planting, growth of trees, suckering, cropping and fruit quality were estimated. Trunk girth at 30 cm above the ground was recorded annually for each tree. Root suckers were counted and then removed during the vegetative period. Length of shoots was measured in the first 3 years after planting for 1 tree from each treatment. Since the fourth year, the width and height of each plum tree were recorded. Crown volume was calculated upon the formula for the volume of cone. Fruit size was estimated as a mean weight of 25 fruits per tree.

The results were statistically evaluated by an analysis of variance. The significance of differences between means was evaluated by Student's t - test at P=0.05.

RESULTS AND DISCUSSION. Among the estimated rootstocks, 'Pixy' appeared to be the most sensitive to frost. After the severe winter of 1996/97 (January: minimum temperature at ground level about minus 20 °C, no snow), 16 trees on this rootstock died (33%). These results are consistent with observations by Boyhan et al. (1998), who found only a 47% survival of plum trees on 'Pixy'. On the contrary, in

English and Dutch climatic conditions all trees on this rootstock survived until the 6th-9th year after planting (Webster and Wertheim, 1993). During the same winter, there were no frost injures observed on trees grafted on other rootstocks. Until 2001, only 2 dead trees were recorded on 'Wangenheim Prune' seedlings (4%).

Until the 7th year after planting, vegetative growth was significantly affected by the cultivar (Tab. 1). The influence of rootstocks was not so clear. 'Čačanska Najbolja' was the most vigorous, while 'Empress' was characterised by the weakest growth, especially on 'Wangenheim Prune' seedlings. Thus, this rootstock appeared to be not the best solution for 'Empress'. Irrespective of the cultivar, trees grafted on 'Pixy' and 'Wangenheim Prune' seedlings were less vigorous in comparison to 'GF 655/2' and 'St. Julien A' rootstocks. Similar results connected with an influence of 'Pixy' on reducing tree growth were reported by other authors (Sitarek and Grzyb, 1993; Webster and Wertheim, 1993; Barroso, 1998; Botu et al., 1998; Embree et al., 1999; Kosina et al., 2000). With the exception of 'Čačanska Najbolja', trees grafted on 'GF 655/2' had the highest number of root suckers. For 'Čačanska Rana' and 'Oneida' there were significant differences. This fact has been confirmed by Kosina et al. (2000). Trees on 'Wangenheim Prune' and 'St. Julien A' rootstocks produced only few suckers.

In 1996-2001 there were significant yield differences between cultivars (Tab. 2). Total yield per tree during this period was significantly the highest for 'Oneida'. Also, weakly growing 'Empress' trees performed very well, starting to bear fruit very early, in the second year after planting. Other cultivars gave the first crops one year later. Only a few fruits until the 7th season were picked from 'Čačanska Rana' trees. This cultivar was most productive on 'Wangenheim Prune' seedlings. Total yield per tree of 'Empress', 'Oneida' and 'Čačanska Najbolja' during 1996-2001 was the highest on 'GF 655/2' rootstock (107.4, 101.8 and 47.8 kg/tree, respectively). Yields of trees on 'Pixy' were lower than on other rootstocks, with the exception of 'Empress' cv., for which the lowest crops were obtained on 'Wangenheim Prune' seedlings. These results are similar to those reported in literature. Riesen and Husistein (1992), Ystaas et al. (1994) and Kosina et al. (2000) found that plum trees produced the

highest yields on ‘GF 655/2’ (big trees) and the lowest on ‘Pixy’ (rather small trees).

Table 1. Vegetative growth of several plum cultivars grafted on different rootstocks

Cultivar/rootstock	Trunk cross-sectional area [cm^2]		Total shoot length 1995-97 [cm]	Volume of crown in autumn’01 [cm^3]	Number of suckers per tree 2001
	autumn 2001	annual increment			
‘Čačanska Rana’					
‘Wangenheim Prune’*	56.7	11.2	3077	6.85	2.2
‘GF 655/2’	79.5	17.4	4880	10.09	17.3
‘Pixy’	60.0	15.8	2084	4.07	5.8
‘St. Julien A’	70.5	13.8	3546	7.58	0.2
Mean for cultivar	**66.7**	**14.6**	**3397**	**7.10**	**6.4**
‘Čačanska Najbolja’					
‘Wangenheim Prune’*	73.0	13.9	2699	5.83	2.8
‘GF 655/2’	90.0	17.6	4508	9.97	15.4
‘Pixy’	91.5	19.9	2558	5.14	17.9
‘St. Julien A’	103.9	20.9	3386	9.46	0.1
Mean for cultivar	**89.6**	**18.1**	**3288**	**7.60**	**9.1**
‘Empress’					
‘Wangenheim Prune’*	22.0	1.8	1959	2.37	0.1
‘GF 655/2’	34.9	3.3	2753	3.75	1.8
‘Pixy’	28.7	2.8	2411	2.79	0.0
‘St. Julien A’	-	-	-	-	-
Mean for cultivar	**28.5**	**2.6**	**2374**	**2.82**	**0.6**
‘Oneida’					
‘Wangenheim Prune’*	53.5	6.2	2717	5.08	1.1
‘GF 655/2’	65.3	6.8	4279	6.72	8.4
‘Pixy’	-	-	-	-	-
‘St. Julien A’	-	-	-	-	-
Mean for cultivar	**59.4**	**6.5**	**3498**	**5.90**	**4.8**
$LSD_{0.05}$ for cultivar	5.8	2.0	484	0.63	2.4
$LSD_{0.05}$ for rootstock within cultivar	11.5	3.9	969	1.26	4.9

* Generative rootstock

Table 2. Cropping of several plum cultivars grafted on different rootstocks (trees planted in spring of 1995)

Cultivar/rootstock	Yield [kg/tree]					Total yield 1996-2001 [kg/tree]	Total yield 1996-2001 [t/ha]
	1996-1997	1998	1999	2000	2001		
'Čačanska Rana'							
'Wangenheim Prune'	4.7	2.4	2.5	3.9	16.7	30.2	37.8
'GF 655/2'	5.3	2.7	5.2	2.2	8.1	23.5	29.4
'Pixy'	1.5	1.1	1.1	1.0	7.2	11.9	14.9
'St. Julien A'	1.5	1.9	3.5	3.3	12.1	22.3	27.9
Mean for cultivar	**3.3**	**2.0**	**3.1**	**2.6**	**11.0**	**22.0**	**27.5**
'Čačanska Najbolja'							
'Wangenheim Prune'	7.4	8.0	6.3	6.2	16.7	44.6	55.8
'GF 655/2'	10.7	11.3	8.9	5.3	11.6	47.8	59.8
'Pixy'	5.1	5.0	2.1	5.1	12.9	30.2	37.8
'St. Julien A'	7.8	7.3	7.5	5.7	12.2	40.5	50.6
Mean for cultivar	**7.8**	**7.9**	**6.2**	**5.6**	**13.4**	**40.9**	**51.1**
'Empress'							
'Wangenheim Prune'	8.3	7.7	9.9	12.7	23.4	62.0	77.5
'GF 655/2'	16.4	11.4	22.2	18.4	39.0	107.4	134.3
'Pixy'	10.8	8.0	7.5	14.9	25.3	66.5	83.1
'St. Julien A'	-	-	-	-	-	-	-
Mean for cultivar	**11.8**	**9.0**	**13.2**	**15.3**	**29.2**	**78.6**	**98.3**
'Oneida'							
'Wangenheim Prune'	4.9	6.1	10.1	20.0	43.5	84.6	105.8
'GF 655/2'	7.0	11.6	13.2	20.1	49.9	101.8	127.3
'Pixy'	-	-	-	-	-	-	-
'St. Julien A'	-	-	-	-	-	-	-
Mean for cultivar	**5.9**	**8.9**	**11.7**	**20.1**	**46.7**	**93.2**	**116.5**
$LSD_{0.05}$ for cultivar	1.3	1.5	2.2	2.3	3.8	8.2	
$LSD_{0.05}$ for rootstock within cultivar	2.5	3.0	4.4	4.6	7.6	16.4	

Among the cultivars tested significantly the largest fruit was produced by 'Empress' trees (Tab. 3). Type of rootstock had no significant influence on fruit size. 'Pixy' showed no negative effect on mean fruit weight in 5 years, either. Fruits from 'Empress' trees were

Table 3. Blooming intensity, mean fruit weight and crop efficiency index (CEC) of four plum cultivars grafted on different on rootstocks

Cultivar/rootstock	Blooming intensity in 0-5 scale* 2001	Mean fruit weight [g]		CEC 1996-2001 [kg/cm^2]
		2001	1997-2001	
'Čačanska Rana'				
'Wangenheim Prune'	3.8	60	55	0.53
'GF 655/2'	3.5	63	56	0.30
'Pixy'	3.8	65	53	0.20
'St. Julien A'	3.9	61	53	0.32
Mean for cultivar	**3.8**	**62**	**54**	**0.34**
'Čačanska Najbolja'				
'Wangenheim Prune'	4.2	60	54	0.61
'GF 655/2'	4.3	61	55	0.53
'Pixy'	4.4	60	53	0.33
'St. Julien A'	4.6	62	55	0.39
Mean for cultivar	**4.4**	**61**	**54**	**0.47**
'Empress'				
'Wangenheim Prune'	4.4	51	57	2.82
'GF 655/2'	4.4	49	58	3.08
'Pixy'	4.0	53	60	2.32
'St. Julien A'	-	-	-	-
Mean for cultivar	**4.3**	**51**	**58**	**2.74**
'Oneida'				
'Wangenheim Prune'	3.7	45	57	1.58
'GF 655/2'	3.1	50	57	1.56
'Pixy'	-	-	-	-
'St. Julien A'	-	-	-	-
Mean for cultivar	**3.4**	**48**	**57**	**1.57**
$LSD_{0.05}$ for cultivar	0.2	3	1	0.15
$LSD_{0.05}$ for rootstock within cultivar	0.5	6	3	0.34

* 0 – tree without flowers; 5 – very abundant blooming

even bigger on 'Pixy' than on other rootstocks. This is in agreement with the results of Riesen and Husistein (1992), who noted a similar fruit size on 'Pixy', 'GF 655/2' and 'St. Julien A'. By contrast, other scientists found that trees on 'Pixy' produced smaller fruits (Ystaas et

al., 1994; Webster and Wertheim, 1993; Grzyb et al., 1998; Embree et al., 1999). Crop efficiency index (CEC) was the highest for weakly growing 'Empress' cv. (2.74 kg/cm^2) and clearly the lowest for 'Čačanska Najbolja' and 'Čačanska Rana' (0.47 and 0.34 kg/cm^2, respectively). Cumulative yield efficiency for both latter cultivars was the highest on 'Wangenheim Prune' seedlings and for 'Empress' on 'GF 655/2'. Trees on 'Pixy' had the lowest CEC but differences compared to other rootstocks were significant only for 'Empress'. These results are consistent with observations by Boyhan et al. (1998) who reported that the yield efficiency of Producer plum cultivar was significantly lower on 'Pixy'.

CONCLUSIONS

1. Frost injures, which were observed on 'Pixy' rootstock, considerably limit its suitability for Polish climatic conditions.
2. Data obtained proved that 'Empress' and 'Oneida' appeared to be the most profitable among the evaluated plum cultivars because of their high and early cropping and quality of fruit. Symptoms of plum pox on fruit of these cultivars did not cause any problem.
3. The best rootstock for 'Empress', 'Oneida' and 'Čačanska Najbolja' cvs. was 'GF 655/2' and for 'Čačanska Rana' – 'Wangenheim Prune' seedlings.
4. Most root suckers were found on trees grafted on 'GF 655/2' rootstock.

REFERENCES

Barroso J. 1998. Evaluation of different rootstocks for 'Greengage' plum. ACTA HORT. 478: 331-339.

Botu I., Achim G., Badea J. 1998. Behaviour of some plum rootstocks in Romania's conditions. ACTA HORT. 478: 229-237.

Boyhan G.E., Norton J.D., Pitts J.A., Himelrich D.G. 1998. Growth, yield, survival and leaf nutrient concentrations of plums on various rootstocks. FRUIT VARIETIES J. 52: 71-79.

Czynczyk A. 1993. Podkładki i odmiany ważniejszych gatunków drzew owocowych. SZKÓŁKARSTWO 1: 13-17.

Embree C.G., Tehrani G., McRae K.B. 1999. Vineland plum cultivars perform well on dwarf and vigorous rootstocks in early production. CAN. J. PLANT SCI. 79: 611-615.

Grzyb Z.S., Sitarek M., Koziński B. 1998. Effect of different rootstocks on growth, yield and fruit quality of four plum cultivars (in central Poland). ACTA HORT. 478: 239-242.

Kosina J., Geibel M., Fischer M., Fischer C. 2000. Evaluation of some new plum rootstocks in the orchard. ACTA HORT. 538/2: 757-760.

Lipecki J., Tarnowicz M., Moryto E. 1994. Zawiązywanie owoców i wstępna ocena plonowania niektórych nowych odmian śliw. Mat. XXXIII Ogólnopol. Nauk. Konf. Sadow. Skierniewice, pp. 106-108.

Łysiak G. 1996. Wzrost i plonowanie 10 odmian śliw zaokulizowanych na dwóch podkładkach w pierwszych 6 latach po posadzeniu. Mat. XXXIV Ogólnopol. Nauk. Konf. Sadow. Skierniewice, pp. 106-107.

Riesen W., Husistein A. 1992. Unterlagenversuch mit Zwetschgen. SCHWEIZERISCHE ZEITSCHRIFT FUR OBST-UND WEINBAU 128: 13-17.

Rozpara E., Grzyb Z.S. 1998. Growth and yielding of some plum cultivars grafted on ‘Wangenheim Prune’ seedlings. ACTA HORT. 478: 87-90.

Sitarek M., Grzyb Z.S. 1993. O perspektywie uprawy śliw na podkładkach słabo rosnących. SZKÓŁKARSTWO 3:12-13.

Sitarek M., Grzyb Z.S., Koziński B. 1995. Wzrost i plonowanie dwóch odmian śliw na różnych podkładkach w pierwszych trzech latach po posadzeniu. Mat. Ogólnopol. Konf. Nauk. Lublin, pp. 131-134.

Sosna I., Szewczuk A., Gudarowska E. 1998. Ocena 11 odmin śliw na podkładce ałycza w rejonie Wrocławia. Mat. XXXVII Ogólnopol. Nauk. Konf. Sadow. Skierniewice, pp. 171-173.

Tehrani G., Leuty S.J. 1987. Influence of rootstock and pruning on productivity, growth and fruit size of European plum cultivars. J. AMER. SOC. HORT. SCI. 112: 743-747.

Ystaas J., Mage F., Husabo P., Frøynaes O. 1994. Performance of Eruni and Pixi as rootstocks for European plum cultivars in a northern climate. NORW. J. AGRIC. SCI. 8: 115-126.

Webster A.D., Wertheim S.J. 1993. Comparisons of species and hybrid rootstocks for European plum cultivars. J. HORT. SCI. 68: 861-869.