

Krymsk[®]1 (VVA-1), a Dwarfing Rootstock Suitable for High Density Plum Orchards in the Netherlands

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Keywords: *Prunus domestica*, ‘Avalon’, economics, ‘Excalibur’, ‘Ferlenain’, fruit quality, graft compatibility, ‘Pixy’, ‘Oteşani 8’, ‘Opal’, production efficiency, ‘St. Julien A’, tree vigour, ‘Victoria’

Abstract

Krymsk[®]1 (*Prunus tomentosa* × *Prunus cerasifera*) was selected by Gennady Eremin at the Krymsk Breeding Station in Russia in 1966. Since 1994, it has been tested as a rootstock for several plum cultivars in The Netherlands. Graft compatibility was good for scion cultivars ‘Avalon’, ‘Excalibur’, ‘Jubileum’, ‘Opal’, and ‘Victoria’. Growth and production efficiency of plum on Krymsk[®]1 was compared with that of plum on St. Julien A and, depending on the cultivar, also with Ferlenain, Oteşani 8 and Pixy. With all cultivars, trees on rootstock Krymsk[®]1 were by far the least vigorous, most precocious, and most production efficient. The production efficiency of ‘Avalon’ and ‘Excalibur’ on Krymsk[®]1 grown for 10 years was 0.41 and 0.26 kg/cm² trunk cross sectional area, respectively, 3.4 and 4.3 times higher on Krymsk[®]1 than on St. Julien A. With ‘Opal’ the production efficiency calculated over the first 5 years after planting was 2 to 3 times higher than on St. Julien A, but this difference became non significant after 7 years of cultivation. This was due to the much higher increase in production per tree during the 5th and 6th leaf of the trees on St. Julien A than on Krymsk[®]1. Fruit size of ‘Opal’, ‘Avalon’ and ‘Excalibur’ was similar for trees grown on Krymsk[®]1 and St. Julien A. With ‘Victoria’ fruit size was significantly larger (5 g) with Krymsk[®]1 than with St. Julien A. Krymsk[®]1 also increased the percentage of first pick by 15%, the sugar content by 9%, enhanced the development of fruit overcolour and reduced the percentage of fruits with gummosis in ‘Victoria’ plums. Dutch fruit growers show great interest in Krymsk[®]1 as a rootstock for plum, as this rootstock makes high density plum orchards feasible. Growers switching to trees on Krymsk[®]1 have to take more care of their trees, especially in the first years after planting. Pruning, irrigation, and fertilization of the trees need much more attention in order to keep the trees vigorous and ensure good production levels. From 2002 to spring 2008, 120,000 plum trees on Krymsk[®]1 have been planted in The Netherlands and planting densities have increased from 830 up to 2,285 trees/ha. The main cultivar planted is ‘Victoria’.

INTRODUCTION

In the Netherlands, European plums (*Prunus domestica*) are grown on about 431 ha at 748 fruit farms (Peppelman and Groot, 2004). The most popular cultivar is ‘Victoria’, followed by ‘Opal’ and ‘Jubileum’. The plums are grown on fairly large trees due to the use of rather vigorous rootstocks, mainly St. Julien A. Consequently, all cultural practices are time consuming and hence costly. Since 1994, the dwarfing rootstock Krymsk[®]1 (VVA-1), a hybrid rootstock of *Prunus tomentosa* × *Prunus cerasifera* selected by dr. G. Eremin of the Krymsk Breeding Station, Russia, has been tested in the Netherlands with several European plum cultivars (Balkhoven-Baart and Kemp, 2002; Balkhoven-Baart and Maas, 2004; Wertheim and Kemp, 1997). So far, these

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trials have shown that plums on Krymsk[®]1 are less vigorous, more precocious, have higher production efficiencies, increased fruit size, better colour development, and higher sugar levels than trees on St. Julien A rootstocks.

Based on these initial trials Peppelman et al. (2007) estimated the economic performance of high density plum orchard with trees on Krymsk[®]1 rootstock. Economic performance strongly depends on the life span, price of trees on Krymsk[®]1, price level of fruits due to improved fruit quality, and on labour costs for picking and pruning. In this paper these previous experiments are summarised and put together with the results of a continued trial with Victoria on Krymsk[®]1. In addition the first trials of plum trees in commercial high density orchard plantations are described.

MATERIALS AND METHODS

Trial 1

This first trial with Krymsk[®]1 as a rootstock for European plum was planted in 1994 at the site of the former Fruit Research Station in Wilhemadorp. ‘Opal’ was used as the testing cultivar and St. Julien A was used as the standard rootstock. Trees were planted at 4 x 2 m. Rootstocks were replicated four times with two trees per plot. Due to the move of the research station to Randwijk the trial was grubbed in 2000. A more detailed description was published (Balkhoven-Baart and Kemp, 2002).

Trial 2

Trees were planted in 1997 at the site of the new research station in Randwijk. In this second trial the cultivars ‘Avalon’ and ‘Excalibur’ grafted on rootstocks St. Julien A, Krymsk[®]1, Ferlenain and Pixy were compared. Planting distances were 3.6×2 m in 4 replicated plots of 2 trees. Further details of the experimental setup of this trial have been given by Balkhoven-Baart and Maas (2004).

Trial 3

Trees of cultivar ‘Victoria’ grafted on rootstocks St. Julien A, Krymsk[®]1 and Oteşani 8 were planted in 2000 at the site of the research station in Randwijk. Planting distances were 3.5×2 m with 2-3 trees per rootstock per plot in 5 replications.

In all trials trees were irrigated by trickle irrigation. Growth of the trees was evaluated by measuring the trunk girth at 25 cm above the graft union after planting and once or every other year onwards. Fruit production was determined yearly as the number and total kg of fruits per tree. Production efficiency was calculated as the number of fruits per cm² trunk cross sectional area (TCSA). The occurrence of gummosis of fruits of ‘Victoria’ harvested in 2004 to 2007 was graded according a scale of 0 (no gummosis) to 9 (very severe gummosis).

Economic Analysis

The economic performances of plum orchards on the rootstock St. Julien A and Krymsk[®]1 were calculated as described by Peppelman et al. (2007). Peppelman et al. based their calculations of Net Present Value (NPV) and Annuity Net Present Value (ANPV) using planting densities of 830 (4×2 m) and 1,350 trees/ha (3.6×2 m) for trees on St. Julien A and Krymsk[®]1, respectively. In the present paper planting density for trees on Krymsk[®]1 have been raised to 2,285 trees/ha (3.5×1.25 m), a density at which new commercial plum orchards have been planted recently in The Netherlands.

Because of the higher planting densities (2,285 instead of 1,350 per ha) the costs for planting materials were increased from €11,838 to €19,205,50/ha. In addition the hours/ha for orchard lay-out were changed to 55 hrs fixed and 55 hrs casual labour, the fixed labour during the growing season to 100 hrs, and the casual labour for fruit thinning to 300 hrs (1st to 3rd leaf) and 400 hrs (4th to 18th leaf) compared to the values used by Peppelman et al. (2007).

Statistical Analysis

The data were analysed using the ANOVA of the Genstat statistical program (release 8.1). In case of significant differences ($p < 0.05$), LSD values were calculated and used for comparing treatment means in pairs.

RESULTS

Trial 1

Tree vigour of 'Opal' determined as the increase in trunk girth from 1994 to 2000 was 27% less for trees grown on Krymsk[®]1 compared to those grown on St. Julien A (Table 1). Similar fruit production, fruit weight, and production efficiency were observed for 'Opal' grown on both rootstocks. 'Opal' showed smooth graft unions with equal growth in trunk girth of scion and rootstock during the duration of the trial. Tree survival was excellent, not a single tree was lost. Although the observations had to be ended in 2000 because of the move of the research station to Randwijk, several trees were left to grow without any maintenance at the abandoned site in Wilhemindorp and survived well until 2007 when they were finally grubbed.

Trial 2

Growth of both 'Avalon' and 'Excalibur' was significantly reduced when grown on Krymsk[®]1 compared to the standard rootstock St. Julien A. The increase in trunk girth from planting in 1997 until the end of the trial in spring 2006 was linear in time and was reduced by 32 and 38% with rootstock Krymsk[®]1 in 'Avalon' and 'Excalibur', respectively (Fig. 1). With both cultivars the graft union with Krymsk[®]1 was quite smooth, indicating good compatibility and a balanced growth in trunk girth below and above the graft union (Figure 2). Cumulative production per tree from 2000 to 2006 was the highest for trees grown on Krymsk[®]1 and amounted to 45.2 kg/tree for 'Avalon' and 28.0 kg/tree for 'Excalibur' (Table 2). Both cultivars also showed the highest production efficiency, 0.41 kg/cm² TCSA for 'Avalon' and 0.26 kg/cm² TCSA for 'Excalibur', i.e. a 1.8 and 2.1 fold increase, respectively, compared to trees on St. Julien A. Average flower intensity from 1999 to 2006 was significantly higher for both cultivars grown on Krymsk[®]1. On a scale of 1 (no flowers) to 9 (very strong flowering) 'Avalon' and 'Excalibur' had flower intensities of 7.2 and 6.6 compared to 5.4 and 4.7 for trees on St. Julien A, respectively. Flower intensity of both cultivars on rootstocks Pixy and Ferlenain was intermediate between that on Krymsk[®]1 and St. Julien A. The average fruit weight from 2000 to 2006 was 58 g for 'Avalon' and 70 g for 'Excalibur' and was similar for trees St. Julien A and Krymsk[®]1.

Trial 3

Tree size of 'Victoria' was significantly less with rootstock Krymsk[®]1 compared to rootstocks St. Julien A and Oteşani 8. The latter two resulted in similar tree vigour. At the end of the 8th leaf the trunk cross sectional areas (TCSA) of 'Victoria' on Krymsk[®]1, St. Julien A and Oteşani 8 were 30.5, 89.7 and 93.5 cm², respectively.

Cumulative production (2001-2007) per tree of 'Victoria' was somewhat less with rootstock Krymsk[®]1 than with rootstocks St. Julien A and Oteşani 8 (Table 3). However, production efficiency (fruits per cm² TCSA) was more than twice as high for trees on Krymsk[®]1 than for trees on both other rootstocks. Further, Krymsk[®]1 resulted in a 10% increase in the percentage first pick and also in an increase of fruit weight of about 10%. In addition, gummosis of 'Victoria' plums was significantly reduced for trees grown on Krymsk[®]1 (Table 4). The average yield percentage of fruits harvested from 2004 to 2007 without any gummosis was significantly (ca. 9%) higher with rootstock Krymsk[®]1 and the percentages of fruits with moderate and severe gummosis were significantly reduced (ca. 8 and 12%, respectively) compared to both rootstocks St. Julien A and Oteşani 8.

Economics

With the standard production scenario and 2,285 trees per ha on Krymsk[®]1, the production in the first 5 growing years was 40 tons higher than on St. Julien A and rising to 136 tons greater production after a total life span of 18 years (472 in stead of 336 tons/ha). The economic comparison showed an ANPV of 3,073 €/ha for this scenario, a 57% increase compared to a standard orchard on St. Julien A. In the case of a similar tree price (€ 3.50) of trees on St. Julien A and Krymsk[®]1, the ANPV of Krymsk[®]1 is 83% higher than of St. Julien A. The higher investments due to more trees per ha will be compensated by the higher yields on Krymsk[®]1.

Assuming a 10% higher picking performance with trees on Krymsk[®]1, due to the easier pickings with the smaller trees on this rootstock, a 90% higher ANPV was calculated compared to larger trees on St. Julien A.

In case of a 10% increase in the price paid for the fruits of Krymsk[®]1 trees, due to a larger fruit size, better fruit colour, and higher sugar level, the ANPV of Krymsk[®]1 will be 160% higher compared with St. Julien A.

Assuming a reduced life span of only 15 years for Krymsk[®]1 the ANPV will be reduced by € 580/ha but still remain 27% higher than with standard St. Julien A. However, a further reduced life span of only 12 years for Krymsk[®]1 will cause a lower ANPV (-18%) compared to trees on St. Julien A with a life span of 18 years.

DISCUSSION

The introduction of Krymsk[®]1 as a rootstock for plum has renewed the interest of many growers in the Netherlands for growing plums. Without doubt the improved economics of growing smaller trees in higher density orchards, due to an earlier start of fruit production and reduced labour costs for pruning and picking, are the main reasons for the increased interest in growing plums. Also the better fruit quality obtained with the dwarfed trees on Krymsk[®]1 contributes to the improved economics as it increases the trade value of the fruits. The higher investment costs for planting more trees per ha is made up quickly by the higher production levels in the first years after planting. These higher initial production levels will also result in a faster return of investment. Poldervaart and Van Teeffelen (2008) calculated that the time needed to earn back the investments is 4.2 years for a 'Victoria' orchard on Krymsk[®]1 (2,450 trees/ha) compared to 5.6 years on St. Julien A (1,250 trees/ha).

Since 2002 commercial plantings of plums grafted on Krymsk[®]1 have been established in the Netherlands. Until now the trees have been produced solely by nursery Botden and Van Willigen (Sambeek, The Netherlands). In the winter of 2002/2003 the first plum trees on Krymsk[®]1 were sold to Dutch fruit growers. From 2004 to 2006 the sales rapidly increased to about 45,000 trees in 2006 and 42,000 in 2007 (Fig. 3). Cumulative sales of plums on Krymsk[®]1 from 2002 to 2008 amounted 120,205 trees. The most popular cultivars grafted on Krymsk[®]1 were 'Victoria' (56%), 'Opal' (20%), 'Jubileum' (11%). With proper cultivation techniques, e.g. fertilization, irrigation, soil drainage, Zahn pruning method (Zahn, 1986), production of 'Opal' and 'Victoria' can be twice as high per tree on Krymsk[®]1 compared to St Julien A in the first years after planting. With 'Victoria' the production per tree on St. Julien A surpassed that of trees on Krymsk[®]1 in about the 5th leaf due to the larger size of the trees on St. Julien A. With 'Opal' the higher production per tree on St. Julien A started from the 7th leaf onwards. However, because of the higher number of trees per hectare with Krymsk[®]1 (ca. 2,285) than with St. Julien A (ca. 1,250), the productions per hectare of both cultivars of the mature plantings remained the highest for trees on Krymsk[®]1. On the basis of the experiences in commercial orchards so far, yearly production of 29.4 tons/ha of 'Victoria' and 27 ton/ha of 'Opal' seems attainable, an increase of almost 7 and 4.5 tons/ha, respectively, compared to the attainable 22.5 tons/ha for both cultivars on St. Julien A.

However, to be a successful grower of plums on Krymsk[®]1 special care should be taken with the trees. Since the root system of Krymsk[®]1 remains smaller (Devyatov,

1996) than that of St. Julien A, the trees on Krymsk[®]1 need more attention of irrigation and fertilisation to keep the trees healthy and maintain the proper balance between fruit production and shoot growth. If not, the trees will lose vigour and will remain small, fruits will be remain smaller and production levels will remain lower than those of orchards on St. Julien A.

Although the trials carried out to date indicate a large improvement of the economics of plum orchards grown on Krymsk[®]1, this is still based on the assumption that the life span of the trees on Krymsk[®]1 will be as long as those of trees on St. Julien A. Peppelman et al. (2007) calculated that a reduction of three years in the life span compared to the 18 years of trees on St. Julien A will make an orchard on Krymsk[®]1 less profitable than an orchard on St. Julien A. However, the economic calculations in this paper, based a higher planting density of 2,285 trees/ha, showed an even 27% higher ANPV compared 830 trees/ha on St. Julien A in case of a 3 year shorter life span of trees on Krymsk[®]1. Only, in the case of a reduction in life span of six years an orchard on Krymsk[®]1 becomes less profitable (-18%) than on St. Julien A. Fortunately, up to the present the observations in our trials with trees on Krymsk[®]1, indicate they are healthy and have shown no indications of a reduced life span.

ACKNOWLEDGEMENTS

This research was financed by the Dutch Productboard for Horticulture. The authors greatly acknowledge Nursery Botden and Van Willigen for providing the figures of their sales of plum trees grafted on Krymsk[®]1. We also like to thank Mr. Gerard Poldervaart (Dutch Fruit Growers Organisation) for providing the data of the commercial plantings of plums on Krymsk[®]1 in the Netherlands.

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Tables

Table 1. Increase in trunk circumference (Δ Trunk), production, fruit weight and production efficiency of plum 'Opal' on rootstocks St. Julien A and Krymsk[®]1.

Rootstock	Δ Trunk (cm) 1994-2000	Production (kg/tree)		Fruit weight (g)		Fruits/cm ² TCSA*	
		1996 1998	1996 2000	1996 1998	1996 2000	1996 1998	1996 2000
St. Julien A	30.8 a	4.2 a	20.1	40	39	2.1 a	15.6
Krymsk [®] 1	22.4 b	7.7 b	19.1	39	39	6.2 bc	19.8
F-value	<0.001	<0.05	ns	ns	ns	<0.001	ns
LSD0.05	1.67	2.9	-	-	-	1.3	

*TCSA = trunk cross sectional area. Values within a column followed by the same character do not differ significantly. ns = Not significant.

Table 2. Production and production efficiency of plum 'Avalon' and 'Excalibur' on different rootstocks.

Rootstock	kg/tree (1999-2005)		Production efficiency (fruits/cm ² TCSA*) 2005	
	Avalon	Excalibur	Avalon	Excalibur
St Julien A	25.1 cd	13.3 a	0.12 ab	0.06 a
Krymsk [®] 1	45.2 e	28.0 cd	0.41 d	0.26 c
Ferlenain	15.3 a	22.9 bc	0.09 ab	0.13 b
Pixy	29.9 d	18.2 ab	0.21 c	0.10 ab
F-test	p<0.001		p<0.001	
LSD 0.05	6.35		0.063	

*TCSA = trunk cross sectional area. Values within a column followed by the same character do not differ significantly.

Table 3. Production, average fruit weight, % first pick and production efficiency of plum 'Victoria' on different rootstocks.

Rootstock	Production	Fruit weight	1st pick	Production efficiency
	2001-2007 (kg/tree)	2001-2007 (g)	(%)	2008 (fruits/cm ² TCSA*)
St Julien A	77.7 b	47.6 a	32.7 a	17.4 a
Krymsk [®] 1	66.6 a	52.3 b	42.4 b	38.9 b
Oteşani 8	74.2 b	47.4 a	28.9 a	16.3 a
F-test	0.037	0.002	<0.001	<0.001
LSD 0.05	13.0	2.2	5.0	7.0

*TCSA = trunk cross sectional area. Values within a column followed by the same character do not differ significantly.

Table 4. Gummosis in plum ‘Victoria’ grown on different rootstocks.

Rootstock	Gummosis (% yield) 2004-2007			
	None	Light	Moderate	Severe
St. Julien A	40.0 a	22.4	32.6 b	56.0 b
VVA-1	48.9 b	22.1	24.6 a	48.0 a
Oteşani 8	40.2 a	20.4	33.4 b	56.6 b
F-test	0.016	n.s.	0.001	0.038
LSD 0.05	6.2	-	3.9	7.0

Table 5. Net present value (NPV) and annual net present value (ANPV) of with rootstocks Krymsk®1 and St. Julien A calculated with different scenarios.

Rootstock	Scenario	Trees/ha	Life span (years)	NPV (€/ha)	ANPV (€/ha)
St. Julien A	Standard	830	18	22,808	1,951
Krymsk®1	Standard	2285	18	35,917	3,073 (+57%) ⁴
Krymsk®1	€ 3.50/tree ¹	2285	18	41,630	3,561 (+83%)
Krymsk®1	+10% picking perf. ²	2285	18	43,483	3,720 (+90%)
Krymsk®1	+10% fruit price ³	2285	18	59,347	5,077 (+160%)
Krymsk®1	Standard	2285	15	25,880	2,493 (+27%)
Krymsk®1	Standard	2285	12	14,261	1,609 (-18%)

¹standard € 6/tree; ²picking performance; ²due to larger fruits; ³compared to St. Julien A.

Figures

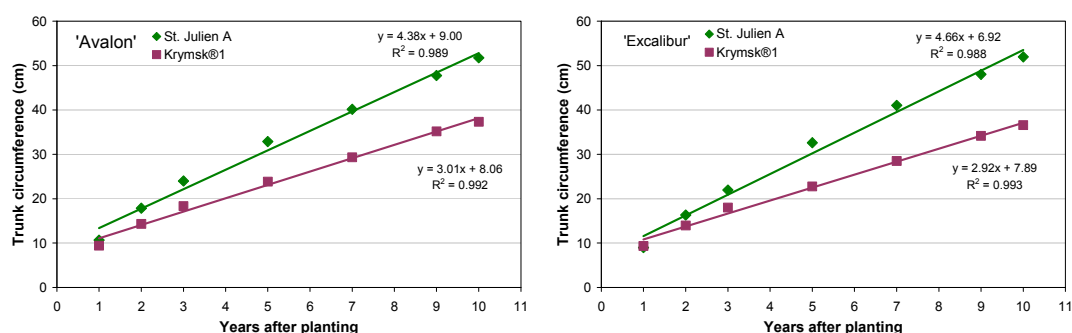


Fig. 1. Increase in trunk circumference from 1997 to 2006 of plums ‘Avalon’ and ‘Excalibur’ on rootstocks Krymsk®1 and St. Julien A.



Fig. 2. Graft unions of 'Avalon' (left) and 'Excalibur' (right) on St. Julien A, Krymsk[®]1 (VVA-1), Ferlenain, Pixy (from left to right) at the end of the 10th leaf.

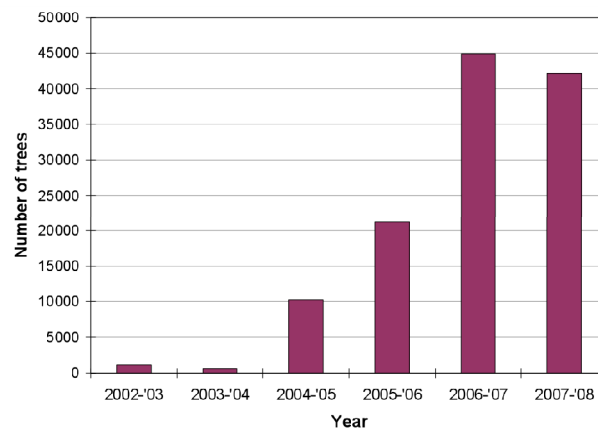


Fig. 3. Commercial sales of plum trees on rootstock Krymsk[®]1 in the Netherlands from 2002 to 2008.