

# PLUM RESEARCH AND GROWING IN LATVIA

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*Plums have been commercially grown in Latvia since the 19<sup>th</sup> century. Plantations expanded especially in the 1920s–1930s. At that time, many cultivars were introduced, mostly from Western Europe. After the severe winters of 1939/40, 1941/42, 1955/56, and 1978/79, the plum orchard area significantly decreased because of a lack of winter-hardy cultivars. For this reason, cultivars from Russia, Belarus, and Estonia were introduced. Among the old landraces, highly winter-hardy ‘Latvijas Dzeltēnā Olplūme’ is still important. Previously it used to be productive and had good fruit quality. Unfortunately, nurseries often propagated the hardiest clones, which lacked productivity. As Latvian consumers love yellow plums, at present breeding and propagation of productive clones from old orchards is ongoing. In the mid-20<sup>th</sup> century, active plum breeding started in Latvia, crossing hardy genotypes with high quality donors. From this period ‘Lāse’ and ‘Minjona’ are still grown. Since the 1980s, plum breeding has been undertaken at the Institute of Horticulture. The crossing work in plums concentrated on the hexaploid group, aiming to combine large fruit size with good flavour, different time of ripening (in particular, early to medium late) and good winter-hardiness. New cultivars include ‘Sonora’, ‘Ance’, and ‘Adelyn’, which have good quality, and productivity 20–30 kg per tree, and in some years up to 70 kg per tree.*

*The most widely used rootstocks are seedlings of *Prunus cerasifera* Ehrh. ssp. *divaricata* C.K. Schneid., which is more hardy than the common myrobalan plum. These rootstocks have good compatibility with most cultivars except gages, and are adapted to different soil types and are disease tolerant. Their drawback is a long growth season which reduces winter-hardiness of grafted cultivars. Also, they tend to form suckers around the stem. A hardy seedling PU-20651 (*P. salicina* ssp. *ussuriensis* × *P. cerasifera*) was bred at the Institute, which was shown to slightly reduce tree vigour. Testing of several Western European and Russian rootstocks did not result in their introduction into production. Trials are presently being carried out with size-reducing rootstocks originated from cultivar Wangenheim VVA-1, Weiwa, S766, and M633.*

*Commercial production of plums in Latvia is relatively small, as the area of orchards is the smallest among fruit trees. Plums are grown mostly for fresh consumption, with a small part for jams, yoghurt, and ice-cream additives. Fruits are sold mostly in small shops, markets and at farms. The main reason is the climate, which allows growing of a limited range of cultivars that tolerate the –30 °C winter temperatures in some years (about every five years). About 20 cultivars are grown commercially; the share of the six most popular plum cultivars is 69% of the total plum production. In recent years, plantations of new cultivars developed at our Institute have expanded, especially regarding the early ripening cultivar ‘Ance’.*

**Key words:** fresh plums, growing areas, cultivars, rootstocks, winter-hardiness.

## INTRODUCTION

Plum production at northern latitudes, where Latvia is situated, is restricted by climatic factors. Introduction and adaptation of cultivars from central and southern parts of Europe or Northern America are very difficult because of their un-

satisfactory hardiness in the climate of Latvia, while winter-hardy cultivars from Russia and Belarus are often lacking in fruit quality. On the other hand, Latvian climatic conditions are favourable for breeding and growing of plums adapted to the local climate. Commercial plum growing in Latvia is constantly developing. However, in spite of long-term

breeding work, the variety assortment of plums is still rather scarce, and particularly, there is a lack of plum cultivars suitable for sale at supermarkets, with large and tasty fruits and satisfactory flesh firmness.

Plums have been commercially grown in Latvia since the 19<sup>th</sup> century. Plantation areas expanded at a large rate in the 1920s–1930s. In 1935, there were 1046 mill. plum trees with average yield of 14–18 kg/tree. Nursery plant production was 12 thousand plum trees, while for 60–70 thousand trees could not be met due to shortage of rootstocks. About 50% of the plums was the landrace 'Latvijas Dzeltenā Olplūme', and the others were Western European cultivars. After the severe winters of 1939/40, 1941/42, when in some places temperatures fell below –40 °C, the area of plum orchards decreased by 50%. The reasons were lack of hardy cultivars and use of growing technologies introduced from countries with different climate (Sudrabs, 1947).

Extreme winters occurred also in the following years, which created the need for breeding and introduction of climate adapted cultivars.

## CULTIVARS

### History of plum variety assortment formation in Latvia.

In early 19th century, the first nurseries for fruit tree production were established in Rīga and in the countryside — nurseries of J. Zigra (in 1803), K. H. Wagner (in 1816) and C. W. Schoch (in 1836). In the 1870s, nurseries were founded by A. von Sievers at Kārļi manor near Cēsis (Wenden), and by S. Klevers in Durbe. Thanks to the large Rīga nurseries that produced plants for the whole Russian Empire, the best Western European and American plum cultivars were introduced to Latvia. Already in 1870, the Schoch nurseries offered 28 plum cultivars (Anonymous, 1870–1871), and in the next years their number approached 100. The assortment of plum cultivars in Latvia since then has been continuously changing, as extreme winters killed cultivars lacking hardiness, and those that did not mature properly in the short summers also were discarded (Kārkliņš *et al.*, 2007).

S. Klevers, who was the first Latvian horticulture publicist, in 1881 recommended to plant the following plum cultivars: with yellow or green fruits — 'Mirabelle de Nancy', 'Mirabelle de Metz', 'Dzeltenā Olplūme', 'Green Gage'; with red and blue fruits — 'Sarkanā Olplūme', 'Perdrigon', 'Tumši Zilā Ķēniņa Plūme' (now unknown), and 'The Czar' (Klevers, 1881).

J. Peņģerots in his book *Augļu dārzs* recommended: 'Green Gage', 'Reine–Claude de Bavay', 'Vidzemes Dzeltenā Olplūme', 'Queen Victoria', 'Kirke', 'Reine des Mirabelles', 'Jefferson', 'Imperial Ottomane', 'Hungarian Prune', 'Anna Späth', and pointing out that the latter two mature only during warm autumns (Peņģerots-Svešais, 1904).

J. Sudrabs wrote, in 1914: "In some places of Vidzeme [i.e. Central and Northern Latvia] plum growing also may be

profitable, but one cannot rely on them; the safest cultivars would be — 'Peach Plum', 'Victoria', 'Green Gage', 'Kirke', 'Vidzemes Dzeltenā Olplūme' ". He also mentioned cultivars 'Duke of Edinburgh' (syn. 'Prince of Wales'), 'Bühler Frühzwetsche', and 'The Czar' (Sudrabs, 1914). Taking into account the damage in severe winters, the Department of Agriculture, in 1921, compiled a list of fruit crop standard cultivars recommending for growing in all regions of Latvia the following plums: 'The Czar', 'Duke of Edinburgh', 'Victoria', 'Green Gage', 'Ontario', 'Mirabelle de Metz', and 'Jefferson' (Sudrabs, 1943). Later severe winters showed that only a few of them were hardy enough.

After the winter of 1928/29, in which stone trees suffered heavy damage, the territory of Latvia was divided into five climate zones for growing apples and pears, but the list of recommended plum cultivars was still recommended for the whole territory, as there was insufficient data about plum hardiness in regions.

After the severe winters of 1939/40, 1941/42, and 1955/56, the plum orchard area significantly decreased. After the winter of 1955/56, it was concluded that cultivars hardy in whole territory were 'Ziedture' (*P. domestica* ssp. *insititia*), 'Mirabelle de Nancy', 'Latvijas Dzeltenā Olplūme', 'Kārsavas' (clone of 'Vengerka Moskovskaya'), and 'Victoria'; perspective cultivars were 'Skoroplodnaya' and Varakļāni clone of 'Latvijas Sarkanā Olplūme'. Cultivars recommended for only southwest and western zones were 'Reine–Claude d'Oullins' and perspective cultivars were 'The First', 'Experimentālfāltets Sviskon', and 'Aizputes', and in the southwest also 'Kirke'. In the central and eastern zones where most plums could not survive, 'Viļakas Plūme' (clone of 'Skorospelka Krasnaya') was recommended as very hardy, but with relatively poor fruit quality. 'Perdrigon', which later proved itself as a highly winter-hardy cultivar, was recommended only for the central zone, as there were only short-term observations (Kārkliņš, 1958; 1966).

After the winter of 1978/79, when temperature in some regions fell even below –40 °C, hardy survivors were 'Latvijas Dzeltenā Olplūme', 'Viļakas', 'Perdrigon' and 'Tartu Punane' (Skriņvele, 1982a; 1982b).

The last extremely cold winter was in 1986/87, again close to –40 °C. Very good or good hardiness was observed for landraces 'Latvijas Sarkanā Olplūme', 'Latvijas Dzeltenā Olplūme', Russian cvs. — 'Otborny Seyanets Evrazii', 'Volzhskaya Krasavitsa', 'Okskaya', Estonian cvs. — 'Polli Viļakas', 'Vilnor', 'Liisu', also 'Experimentālfāltets Sviskon', 'The Czar' and 'Stanley' (Jekovičs, 1988; Kārkliņš *et al.*, 2007).

**Introduction of cultivars in the 2<sup>nd</sup> half of the 20<sup>th</sup> century and beginning of the 21<sup>st</sup> century.** In the second half of the 20<sup>th</sup> century, many Estonian and Lithuanian plum cultivars were introduced to Latvia, where they were tested at Pūre Horticulture Research Station by M. Skriņvele. The

best suitability to Latvian climate was shown by 'Ave', 'Julius', 'Polli Viljakas', and 'Vilnor' from Estonia. The most promising Lithuanian cultivar was 'Rausve' (Gronskis *et al.*, 1988).

'Renklod Sovetsky', 'Krasnoslobodskaya', and 'Sentyabrskaya' were considered as promising cultivars from Russian breeding programmes, as they were well-adapted to the Latvian climate and had satisfactory fruit quality. These cultivars were examined in trials at Pūre by U. Dēķens (Dēķens, 1999).

During the same period, evaluation of Russian cultivars from the so-called Eurasia group was conducted. Eurasia plums were developed by crossing of diploids (mostly cv. 'LaCrescent') with hexaploid plums and subsequently backcrossed to obtain hexaploid material. From cultivars tested at Dobeles, the most promising were 'Aleinaya', 'Zarechnaya Rannaya', and 'Startovaya'. The main reasons of their selection were early ripening, as well as good winter-hardiness, easy tree shape and fruit quality (Ikase and Kaufmane, 1994; Kārkliņš *et al.*, 2007).

Among diploid plum ( $2n = 16$ ) species, only introduction of more hardy Russian cultivars was partially successful. Among these cultivars, the Japanese plum subspecies Ussurian plum (*Prunus salicina* ssp. *ussuriensis* (Kov. et Kost.) Erem.) was characterised as cold-hardy, but in Latvia showed sensitivity to temperature fluctuations in late winter and susceptibility to diseases. Only one cultivar ('Skoroplodnaya') became commercially successful in Latvia, and only in continental regions (Jekovičs, 1972). Later, interspecies hybrids from Russia were introduced, whereby Japanese and Ussurian plums were crossed with myrobalan plum *P. cerasifera* Ehrh. (high disease tolerance), *P. americana* Marsh., *P. nigra* Ait., *P. simonii* Carr., etc. The interspecies hybrids were better adapted in Latvia, but still were susceptible to flower bud damages. The most stable production was shown by 'Kometa Kubanskaya' (syn. 'Kometa'). This species was widely grown in commercial orchards (Ikase, 1998; Kārkliņš *et al.*, 2007).

At the end of the 1990s, testing of cultivars and hybrids selected in Sweden was started at Dobeles. 'Jubileum', one of the most popular commercial cultivars in Scandinavia, and characterised by high fruit quality was considered as most promising for growing in Latvia (Kaufmane *et al.*, 2003).

Since 2008, cultivars created by the outstanding German breeder Walter Hartman were tested at the Institute of Horticulture in Dobeles. Their greatest values were resistance to sharka virus (PPV), good fruit quality and high sugar content. Presently, the most promising cultivar is 'Tegera', which has acceptable winter-hardiness in Latvian conditions and fruits with good storage and suitable for drying (17 Brix°). Good results were shown also by 'Hanita', which has high and regular production and very high fruit quality (20 Brix°), and by hybrid H 3753 (19.2 Brix°). In years with a long and warm autumn, the late-ripening cultivars 'Haganta' and 'Habella' also showed good results, but

in some cooler seasons their fruits did not mature (Grāvīte and Kaufmane, 2017).

Regularly repeating severe winters have proven that hardy cultivars are needed in the Latvian climate, while consumers need attractive, tasty fruits. For this reason, breeding of native plum cultivars has been conducted, along with testing of cultivars introduced from abroad.

**Plum breeding and clone selection in Latvia.** The landrace 'Latvijas Dzeltēnā Olplūme' (Figs. 1–2) has been grown in Latvia for a long time. It is not known where and when the cultivar was formed. It was grown under different names: 'Vidzemes dzeltēnā olu plūme', 'Vidzemes dzeltēnā', 'Zemnieku plūme' etc., at least 100 years or maybe even 200 years ago. In Lithuania it is also considered as an old local cultivar and called 'Vietinė Geltonoji'. In Estonia it is considered as a landrace from Vidzeme (Livland), and its Estonian name is 'Liivi kollane munaploom'. In Russia and Belarus, it is also considered as a cultivar of local origin and called 'Ochakovskaya Zholtaya' or 'Ochakovskaya Belaya' (Skrīvele and Dēķēna, 2017). It is similar but not necessarily identical to other old yellow egg plums in Europe, e.g. 'Allmänt Gulplommon', which has been grown in Sweden possibly since the Middle Ages (Nilsson, 1989). In the course of centuries it has been propagated both by root suckers and seeds, and the most winter-hardy genotypes with better fruit quality have been selected by many growers. In the 1950s, the researcher of the Institute of Biology, Academy of Sciences Antons Spolitis organised expeditions to search for Latvian plum landraces to evaluate. It was found that most 'Latvijas Dzeltēnā Olplūme' trees were found in Northern Latvia around Limbaži, Aloja, Smiltene, Alūksne, and Rūjiena, but also around Aizpute (Western Latvia) and Ludza (Eastern Latvia). The most productive clones with the largest fruits were selected during the expeditions, but these perished in the following severe winters.



Fig. 1. 'Latvijas Dzeltēnā Olplūme': semi-double flowers.



Fig. 2. 'Latvijas Dzeltēnā Olplūme': fruits.





Fig. 3. 'Kārsavas Sarkanā plume'. From: Kārkliņš J. (1958).

Typical traits of the landrace are late flowering and sterile pollen (Spolītis *et al.*, 1955).

Two best clones of another landrace, 'Latvijas Sarkanā Olplūme', were also selected during the expeditions — 'Varakļānu' ('Varakļānu Sarkanā') and 'Krustpils' ('Krustpils Sarkanā'). These clones are more winter-hardy and have better fruit quality than other clones of this landrace. A clone 'Kārsavas' ('Kārsavas Sarkanā') (Fig. 3) was selected from 'Vengerka Moskovskaya', and clone 'Viļakas' — from 'Skorospelka Krasnaya'. In Aizpute, a plum cultivar 'Aizputes' was found, and in the orchards of Vidzeme — also cultivar 'Agrā Sārtā'. In all regions of Latvia, different landraces and clones of small blue damson plums called "būkas" or "kriķes" (*Prunus domestica* ssp. *insititia* (L.) C. K. Schneid.) have been propagated by root suckers during a long time period. Those with the largest fruits were selected as cultivars — 'Kurzemes Būka', 'Vidzemes Būka', 'Latgales Būka' (Spolītis *et al.*, 1955).

In the course of his research of plum fertilisation biology, A. Spolītis made numerous crosses. From the obtained hybrids, promising variety candidates were selected: 'Lāse' — registered in Latvia, and 'Zilā Lāse' (Spoliša 20-1) (Spolītis, 1978; Skrīvele *et al.*, 1999).

Breeder Pēteris Upītis in Dobeles also investigated Latvian plum landraces, and selected the damson plum 'Ziedture'. He also conducted large-scale hybridisation between cultivars and plum species (Mežapuķe, 1969). After his death, since the 1980s, plum breeding at Dobeles was continued by Edīte Kaufmane. Cultivars 'Zemgale' and 'Minjona' were selected and registered from hybrids of P. Upītis (Skrīvele *et al.*, 1999).

The main breeding method of P. Upītis was sowing of open-pollinated seeds. In this way, he obtained relatively winter-hardy and highly productive hybrids of diploid plums — Caucasian subspecies of myrobalan plum (*Prunus cerasifera* Ehrh. ssp. *divaricata* C. K. Schneid.), Ussurian plum (*Prunus salicina* ssp. *ussuriensis* (Kov. et Kost.) Erem.) and their hybrids with other diploid species. From these hybrids, Laila Ikase selected cultivars 'Inese' and 'Agrā Dzeltēnā', previously registered in Latvia (Ikase, 1991; 1993). Now, 'Agrā Dzeltēnā' is growing only as polliniser. In breeding of red-leaf myrobalan plum, good results were achieved by Roberts Āboliņš and Aleksandrs Maizītis at Iedzēni, obtaining the cultivar 'Spīdola', which is still very popular.

Latvian genetic resources collection of diploid plums includes 22 cultivars and hybrids of Latvian origin, obtained from open-pollination or found as chance seedlings. The most interesting is 'Alvis' (syn. 'Veinberga') — a very hardy polleniser. The red leaf ornamental plum cultivars 'Liesma' and 'Gunta' obtained at the Institute of Horticulture are more winter hardy than 'Spīdola'. A winter-hardy hybrid of black apricot *P. × dasycarpa* MA-1 also was selected at the Institute. Unfortunately, all Latvian diploid plums have fruits too small for commercial production and can be used only for processing (Kaufmane, *et al.*, 2002).

In the end of 1990s, the following aims were defined for plum breeding at the Institute:

- Cultivars adapted for growing in Latvia (including high winter-hardiness of flower buds, resistance of trees to low temperatures and harsh temperature changes during the winter-spring period).
- Fruit quality suitable for commercial growing.
- Resistance to the most important diseases.
- Ripening during an extended period of time (the main accent is laid on early maturation).
- Tree habit easy for training and cultivation.
- High degree of self-fertility.

During 1996–2001, a common domestic plum breeding programme with Swedish breeders was carried out. As a result, four new cultivars were released from more than 100 perspective hybrids. The obtained cultivars 'Sonora', 'Adelyn', and 'Ance' are suitable for commercial growing in whole territory of Latvia. In 2017, these cultivars were registered in Latvia. 'Lotte' has tasty and good quality fruits, but its winter-hardiness is not satisfactory in the entire territory of Latvia. It can be recommended for locations with the most favourable conditions (Kaufmane *et al.*, 2012). Application for registration of following two new cultivars from this programme were made in 2016 and 2017 and currently are being tested through the DUS test: 'Laine', which is suitable for commercial cultivation, and 'Zane', which is suitable for growing in home gardens. In recent years, new cultivars have been planted in commercial orchards, and particularly the early ripening 'Ance'.

## POLLINATION

Most of the plum cultivars grown in Latvia are partially or completely self-sterile. Knowledge of the flowering time and suitability of some cultivars as pollenisers is necessary for regular and high production. Numerous studies about pollination and fertilisation have been carried out and the most suitable pollenisers for new cultivars have been examined (Karklins *et al.*, 2007; Gravite and Kaufmane, 2013). Plum cultivars are grouped as very early, early, medium early, medium late and late flowering. Flowering time can highly differ among years. In commercial plantations, it is

Table 1

## GROUPING OF PLUM CULTIVARS BY THEIR FLOWERING TIME IN LATVIA

Flowering time	Cultivars*
Very early	Diploid plums: <b>Agrā Dzeltēnā</b> , <b>Alvis</b> , Kometa, <b>Mara</b> , Naidyona, Skoroplodnaya, <b>Spidola</b>
Early and medium early	Ave, Aleinaya, Ance, Adelyn, <b>Duke of Edinburgh</b> , <b>Experimentalfältets Sviskon</b> , Jubileum, Julius, <b>Kārsavas</b> , Krasnoslobodskaya, <b>Minjona</b> , Oda, Renklod Ranny Donetsk, Renklod Uljanishcheva, Sonora, <b>Reine-Claude d'Oullins</b> (in some years), <b>Victoria</b> , Zarechnaya Rannaya, Zemgale
Medium late and late	<b>Althans Reine-Claude</b> , Kijevas Vēlā, Lāse, Latvijas Dzeltēnā Olplūme, Lotte, <b>Mirabelle de Nancy</b> , <b>Ontario</b> , Okskaya, <b>Perdrigon</b> , Sentyabrskaya, <b>Stanley</b> , <b>Reine-Claude d'Oullins</b> (in some years), Washington, <b>Green Gage</b>

\* In bold – cultivars which are good pollinators

recommended to group cultivars according to their flowering time (Table 1). Closeness of a suitable polliniser is especially important in cool and rainy spring when the pollen is washed off the pistils (Feldmane *et al.*, 2015). ‘Victoria’, the most common cultivar in Latvia is self-fertile and a good polliniser for all medium early flowering cultivars. For pollination of diploid plums, cultivars of the same group with good pollen quality are recommended (pollen germination of diploid plums often is low), but it is more common that pollinisers are seedlings of myrobalan plum (*P. cerasifera* ssp. *divaricata*) (Karklins *et al.*, 2007).

Pollination trials with new cultivars indicated that the only cultivar with self-fertility is ‘Sonora’ (33.5%). The best pollination results for cultivar ‘Adelyn’ were found in combination with cultivar ‘Victoria’ as a polliniser (average fruit set % after June drop — 66.5%). Cultivar ‘Lotte’ showed the best results with ‘Minjona’ as a polliniser (46.6%), and ‘Sonora’ with ‘Experimentalfältets’ (53.9%) (Grāvē and Kaufmane, 2013). Recent research showed that ‘Ance’ is partially self-fertile; in favourable years fruit set with self-pollination was 32%, in less favourable years — 0%.

Also, genotyping by *Sf* (self-incompatibility) gene markers has been conducted at the Institute of Horticulture. A total of 99 plum accessions were genotyped: 7 diploid and 92 hexaploid plums with markers developed for different *Prunus* species. Future development is aimed at detection of plum self-incompatibility groups by allele specific genotyping (Kota and Lacis, 2013).

## ROOTSTOCKS

The most used rootstock in Latvia is seedlings of *Prunus cerasifera* Ehrh. ssp. *divaricata* C. K. Schneid., which is hardier than the common myrobalan plum. This rootstock has good compatibility with most cultivars except gages. It is also well adapted to different soil types. It is disease tolerant. A drawback is due to a long growth season, which re-

duces winter-hardiness of grafted cultivars and tendency to form suckers around stems.

The hardy seedling PU-20651 (*P. salicina* ssp. *ussuriensis* x *P. cerasifera*) has been selected at the Institute of Horticulture, which slightly reduces tree vigour (Kaufmane *et al.*, 2007a).

Testing of several Western European and Russian rootstocks at the Institute of Horticulture during the period of 1995–2015 (St Julian A, St Julian GF 655/2, Myruni, AP-1, SVG 11-19, OP 23-23, Druzhba) did not show the expected results in production, and only St Julian GF 655/2 and AP-1 had satisfactory winter-hardiness (Kaufmane *et al.*, 2007).

Dz. Dēķena performed long-term trials with cultivars ‘Victoria’ and ‘Kometa’ on 16 rootstocks of different origin and vigour. The best results for a complex set of parameters (winter-hardiness of tree and generative buds, productivity, fruit set etc.) in Latvia’s conditions for both cultivars were recorded for the vigorous rootstock ‘Brompton’, as well as ‘Wangenheim’, which reduced tree vigour (Dēķena *et al.*, 2017). A study with several Reine-Claude type cultivars showed that tree vigour on ‘Wangenheim’ rootstock was reduced approximately 30%, and that the yield per tree of all cultivars was also lower.

Current trials are being continued with ‘Wangenheim’ rootstocks and size-reducing VVA-1, Weiwa, S766 and M633. Preliminary results showed that: (1) the most vigorous rootstocks were *P. cerasifera* and Weiwa; (2) other rootstocks had no significant differences in vigour; (3) ‘Victoria’ had significantly smallest trees on VVA-1; (4) ‘Jubileum’ showed significant differences among rootstocks (VVA-1 decreased TCSA about 30%; S 766 decreased TCSA about 15% compared with trees of seedling rootstock *P. cerasifera*; (5) the rootstocks *P. cerasifera*, S766 and M633 showed higher occurrence of suckers in both years of testing. An effect of cultivar on root suckering was not significant.

## ORCHARD MANAGEMENT

In the period of 1945–1991, research of plum growing technologies involving planting distances, tree training, fertilising, maintenance of tree rows and alleyways was conducted at the Pūre Horticulture Research Station. At that time plums were grown only on seedlings of *P. cerasifera* Ehrh. spp. *divaricate* (Fig. 4). Planting distances for vigorous cultivars were 4 × 6 m, but for weaker growing cultivars — 3 × 5 m. In alleyways, it was recommended to maintain bare fallow to keep free of plant growth within tree rows and to grow intercrops between the tree rows (Gronskis and Ūdris, 1988). Often it was recommended to train trees as bushes to reduce winter damages (Jekovičs, 1972).

In the late 1990s, research of plum growing technologies was started at Dobeļe, Institute of Horticulture. The main focus was on the effect of different cultivar-rootstock combinations on fruit quality, productivity, tree training and





Fig. 4. Typical Latvian plum orchard on *P. cerasifera* rootstocks.

various methods of soil maintenance in rows. At present in Latvian conditions plum seedlings of *P. cerasifera* Ehrh. spp. *divaricata* are recommended to plant at 3–4 m × 4–5 m distances: 500–830 trees per ha, depending on tree vigour. The most popular crown shapes are vase and spindle. Taking into account the Latvian climate, suitable trunk height for plums is 60–80 cm. Grass is grown in alleyways, while tree rows are maintained free of weeds by mulching, herbicides or mechanically (Gravite and Skrīvele, 2015; Skrīvele and Rubauskis, 2015).

Nowadays trials on different crown shapes, and their influence on productivity and fruit quality are carried out at the Institute. The aim of this research is to develop an effective pruning system for new Latvian cultivars, which provides the highest yield and fruit quality, along with earlier start of production (Fig. 5). Vegetative growth is reduced if trees have higher yield, because the intake of nutrients is diverted to form fruit buds and fruits. For high fruit quality, in our climate is very important to create and maintain an open tree crown without very strong new growth.

#### PLUM COMMERCIAL GROWING IN LATVIA

Commercial production of plums in Latvia is relatively small, which is the smallest among fruit trees (Table 2). The main reason is the climate, which allows to grow a limited range of cultivars tolerating –30 °C winter temperatures, which occur about every five years, and also temperature fluctuations in late winter. With a right choice of site, cultivars and orchard management, plums can give high yields in larger commercial orchards.

Plums are grown mostly for fresh consumption, while a small part is used for jams, yoghurt and ice-cream additives. Fruits are sold mostly in smaller shops, markets and at farms. Only 2–5 cultivars are available in the supermarkets, of which the most popular are ‘Kometa’ (Fig. 6) and ‘Victoria’.

About 20 cultivars are grown commercially (Table 3). The share of the six most popular plum cultivars (‘Kometa’,



Fig. 5. Mechanical pruning of plums on *P. cerasifera* rootstocks.

Table 2

AREAS OF COMMERCIALY GROWN FRUIT TREES IN LATVIA (YEAR 2018)

Crop	Total area (ha)	Including organic (ha)
Apples	2844.17	434.47
Pears	155.95	9.8
<b>Plums</b>	<b>95.22</b>	<b>26.4</b>
Cherries	121.98	12.37

Data from Rural Support Service about declared areas larger than 0.3 ha: <http://www.lad.gov.lv/lv/statistika/platibu-maksajumi/periods-2004-2016/statistikas-dati-par-2018-gadu/>



Fig. 6. ‘Kometa’: fruits.

‘Victoria’, ‘Duke of Edinburgh’, ‘Reine-Claude d’Oullins’, ‘Skoroplodnaya’, ‘Julius’) is 69% of the total plum production. In the last years, plantations of new cultivars developed at our institute have expanded, especially the early ripening cultivar ‘Ance’. Also the Swedish cultivar ‘Jubileum’ has become more and more popular.

Other cultivars also commercially grown in Latvia are: ‘Reine-Claude d’Althaus’, ‘Aleinaya’, ‘The Czar’, Experimentalfältets Sviskon’, ‘Emma Leppermann’, ‘Kārsavas’,

Table 3

## CHARACTERISATION OF PLUM CULTIVARS RECOMMENDED FOR GROWING IN LATVIA

Cultivar, origin	Tree	Ripening time	Fruits	Flowering time, self-fertility	Production	Winter-hardiness, tolerance to diseases
Recommended for commercial orchards in all Latvia:						
<b>Ave</b> Estonia	Medium vigour, upright	Early	Medium, dark purple, flavour very good, stone free	Medium early, self-sterile	Productivity highly dependent on polliniser	Tree hardy, flower buds – medium hardy; tolerant to diseases
<b>Kometa</b> (Kubanskaya Kometa; <i>P. salicina</i> × <i>cerasifera</i> ) Russia	Medium vigour, spreading	Very early	Medium, raspberry red, flavour good, stone separates only for tree-ripe fruits	Very early, self-sterile, poor pollen	Early and high, regular, very good transportability	Tree and buds hardy; tolerant to diseases
<b>Lāse</b> Latvia	Medium to vigorous, upright, dense	Medium early	Medium to large, yellow, flesh firm, flavour medium, freestone	Late, self-sterile, poor pollen	Productivity highly dependent on polliniser; poor transportability	Hardy; medium tolerant to diseases
<b>Perdrigon</b> Western Europe	Medium vigour, upright spreading	Medium late	Medium, dark purplish blue, flavour mediocre, stone separates only for tree-ripe fruits	Medium late, self-fertile, good polliniser	Productive, regular yields	Tree and flower buds hardy; tolerance to diseases good to medium
<b>Skoroplodnaya</b> Russia ( <i>P. salicina</i> )	Vigorous, needs regular heading back of shoots and crown renewal	Early	Medium, bright red, flavour good, stone small, semi-free; do not crack in rainy weather	Very early, self-sterile, poor pollen	Very early and good, but depends on flower bud winter damages; good transportability	Hardy in continental winters, susceptible in thaws; tolerant to diseases
<b>Victoria</b> United Kingdom	Medium vigour, needs regular crown renewal	Medium late	Medium, over-colour dark pink, flavour good, freestone	Medium early, self-fertile, good polliniser	Very early, productive, holds well on tree	Hardy, if high yields are thinned; tolerant to fruit rot
Recommended for best orchard sites:						
<b>Duke of Edinburgh</b> (Prince of Wales) United Kingdom	Vigorous, upright spreading, needs regular crown renewal	Medium late	Over medium size, dark purplish with bloom, flavour good, stone separation poor	Medium early, self-fertile, good polliniser	Early and good	Medium, better if high yields are thinned; rather susceptible to fruit rot
<b>Jubileum</b> Sweden	Very vigorous, needs careful training	Medium	Large to very large, dark purplish, flavour good; stone semi-free, rather thick skin	Medium early, partially self-fertile	High, needs irrigation for good quality	Hardy (tested short-term); medium tolerant to diseases
<b>Julius</b> Estonia	Medium to small	Early	Medium, purplish or pink, flavour very good, stone semi-free	Medium early, self-sterile	Good, rather regular	Medium hardy; susceptible to shot-leaf
<b>Kijevs Vēlā</b> Ukraine	Medium, spreading	Medium late	Large, dark purplish blue, flavour very good, stone semi-free	Medium late, self-sterile	Good	Medium hardy; susceptible to fruit rot after cracking in rain
<b>Minjona</b> Latvia	Small, spreading, needs regular crown renewal	Medium early	Medium or smaller, dark brownish purple, flavour good, freestone	Medium early, fully or partly self-fertile	Early and good, regular; ripe fruits fall easily	Hardy; medium tolerant to diseases
<b>Oda</b> Ukraine	Rather small, compact; needs regular crown renewal	Medium early	Medium, dark blue, flavour good, stone semi-free, stone tip often breaks	Early, self-sterile	Early and good, regular	Tree medium hardy, flower buds hardy; medium tolerant to diseases
<b>Ontario</b> USA	Medium to vigorous	Early	Large, greenish yellow, flavour good, freestone	Late, fully or partly self-fertile	Good, regular	Medium hardy, medium tolerant to diseases

Table 3 (continued)

Cultivar, origin	Tree	Ripening time	Fruits	Flowering time, self-fertility	Production	Winter-hardiness, tolerance to diseases
<b>Renklod Ranny Donetsk</b> Ukraine	Medium, spreading	Medium early	Large, light yellow with blush, flavour good, stone separation good for thinned fruits	Early, self-sterile	Early and good, regular; transportability poor	Medium hardy; rather susceptible to fruit rot
<b>Reine-Claude d'Oullins</b> France	Very vigorous, upright spreading	Medium early	Medium to large, greenish yellow, flavour very good, clingstone	Medium late, self-fertile, good pollinator	Late start of production, productive; transportability poor	Medium hardy; susceptible to fruit rot when cracking
<b>Sentyabrskaya</b> Ukraine	Small or medium, upright spreading	Medium late	Medium to large, dark blue with bloom, flavour good to very good, freestone	Medium late, self-sterile	Early and good	Medium hardy (short-term data); susceptible to fruit rot when cracking
<b>Stanley</b> USA	Medium, upright, later upright spreading	Very late	Medium to large, dark purple, dark purple with bloom, flavour good to very good, freestone	Late, partly self-fertile	Early and good, regular; transportability good	Hardy, but needs a long growth season
<b>Zarechnaya Rannaya</b> Russia	Vigorous, spreading, sparse	Early	Medium to large, dark purplish, flavour good to very good, freestone	Early, self-sterile	Early, productivity differs between orchard sites	Hardy (short-term data)
Perspective cultivars:						
<b>Adelyn</b> Latvia	Medium, upright spreading, easy training	Medium early	Large, yellow with blush, freestone; good storage	Medium early, self-sterile	Early, high, regular; transportability medium	Hardy (short-term data); tolerant to diseases
<b>Ance</b> Latvia	Vigorous, upright spreading, with good branching	Very early	Medium to large, yellow with blush, flavour good, freestone	Medium early, partly self-fertile (short-term data)	Early, high, regular; holds well on tree	Hardy; medium tolerant to diseases
<b>Laine</b> Latvia	Medium, spreading, with good branching	Medium late	Very large, purple with pale yellow flesh, firm, freestone	Medium early	High	Hardy (short-term data); medium tolerant to diseases
<b>Lotte</b> Latvia	Medium, spreading	Medium late	Medium, dark purplish blue, sweet, freestone	Medium late, partly self-fertile (short-term data)	Early, medium productive	Satisfactory only in best locations, trunk susceptible to winter injury; medium tolerant to diseases
<b>Renklod Sovetsky</b> Russia	Medium, upright spreading	Medium early	Large, dark purple with bloom, firm, flavour good, freestone	Medium early, self-sterile	Early, good; very good transportability	Medium hardy and medium tolerant to diseases (short-term data)
<b>Sonora</b> Latvia	Medium, easy to train, needs regular crown renewal	Medium late	Large, purplish with bloom, flavour good for tree-ripe fruits, stone semi-free	Medium early, self-fertile	Early, good, regular; needs several pickings	Medium hardy and medium tolerant to diseases
<b>Tegera</b> Germany	Rather vigorous, upright to spreading	Medium early	Medium to large, purplish blue with bloom, firm and juicy, freestone	Medium late, self-fertile	Early, high, regular, very transportable, hold well on tree	Medium hardy and medium tolerant to diseases (short-term data)
<b>Zane</b> Latvia	Spreading, with very nice, healthy foliage	Early	Large, light purple, flesh greenish, very tasty, stone semi-free	Medium	Medium productive, regular, needs several pickings	Medium hardy and medium tolerant to diseases (short-term data)



'Latvijas Dzeltēnā Olplūme', 'Grand Duke', 'Mirabelle de Nancy', 'Okskaya', 'Ontario', 'Renklod Ulyanishcheva', 'Suhkruploom', 'Tragedy', 'Reine Claude Verte', etc. Diploid plum cultivars include also 'Mara', 'Naidyona', 'Spīdola', pollenisers 'Alvis' and 'Agrā Dzeltēnā' (Kaufmane, 2015).

The main plum season in Latvia starts at the end of July (diploid plums and some domestic plums — 'Aleinaya', 'Polli Varane', 'Ance', 'Startovaya'). Most of the cultivars are harvested in August and beginning of September (also the most popular — 'Victoria'). The latest cultivars that are possible to grow in Latvia, are 'Stanley', 'Grand Duke', and 'Giant', which ripen in the end of September or beginning of October.

The productivity in the best large orchards in Soviet times was 12–13 t/ha. Then the fruits were mostly grown for processing (jams, juices, and compotes), and prices were very low. At present, statistical data of yields in Latvia are incomplete, as well as data about the local market, because plums are sold mostly on farms and at farmer markets. Only a small share goes to supermarkets.

Questioning of the largest growers showed that the average yield of mature trees is 20–25 kg/tree (12–14 t/ha) for domestic plums and 35–40 kg/tree (19–22 t/ha) for the diploid plum 'Kometa'. At our Institute the average yield is ~30 kg/tree (~20 t/ha). The most productive cultivars are 'Sonora' (max. 46 kg/tree), 'Ance' (max. 70 kg/tree), 'Jubileum' (max. 75 kg/tree) and 'Victoria' (max. 67 kg/tree).

Price depends on the the annual yield. In 2018, it was 1.3–1.7 EUR/kg for fruits were sold to supermarkets. Imported plums (Poland, etc.) are cheaper (0.6–0.8 EUR/kg) and create hard competition. When the plums are sold on a farm or at a farmers market, the price varies from 2 EUR/kg (early cvs.) to 1 EUR/kg in the main season.

## MAIN PLUM DISEASES IN LATVIA

**Virus diseases.** *Plum pox virus* (PPV) or sharka is one of the most devastating viruses to plum production in the world. In the last 30 years, it has spread rapidly, and today PPV can be found in nearly all plum growing regions worldwide (Hartman and Neumüller, 2013). In Latvia it is in the list of quarantine diseases, and the Plant Protection Service carries out regular monitoring of orchards. In Latvia PPV was found in a few cases in home gardens and collections, but not in commercial plantations.

To evaluate the occurrence of *Plum pox virus* (PPV) and eight other viruses infecting *Prunus*, a large-scale survey and sampling in Latvian plum orchards was carried out. Occurrence of *Apple mosaic virus* (ApMV), *Prune dwarf virus* (PDV), *Prunus necrotic ringspot virus* (PNRSV), and *Apple chlorotic leaf spot virus* (ACLSV) on plums also was investigated by RT-PCR and DAS ELISA detection methods. The study demonstrated that stone fruit viruses are relatively not widespread in plum orchards in Latvia and that

the commonly grown genotypes are infected with one or more of the tested viruses. In the future, the implementation of a programme to produce and propagate virus free planting material, along with the establishment of virus free planting material collections and certification programmes in the country, will play the key role for the containment of the spread of these viruses in the orchards (Gospodaryk *et al.*, 2013).

**Bacterial diseases.** Bacterial diseases are economically important and widespread on stone fruits worldwide. The bacterial diseases of stone fruits have not been studied in Latvia, and the identification of causal agents has not been carried out previously. Eleven farms were surveyed in 2008–2011 to determine and evaluate the occurrence of pathogenic *Pseudomonas syringae* on plums (*Prunus domestica* L.) in different regions of Latvia. Pathogenic *P. syringae* was detected in samples only from three farms. The low occurrence of pathogenic *P. syringae* showed that severe symptoms observed on plums in orchards are also caused by other plant pathogens (Konavko *et al.*, 2017).

**Fungal diseases.** Plum rust (caused by *Tranzschelia prunispinosae* (Pers.) Dietel.) in some years spreads in commercial plantations, especially when no phytosanitary prophylaxis is done. In the case of widespread infection it may be harmful to trees.

Shot leaf disease (caused by *Wilsonomyces carpophilus* Lev. syn. *Stigmina carpophila* (Lev.) M. B. Ellis) is common in commercial orchards, and damaging in some cases.

Silver leaf disease (caused by *Chondrostereum purpureum* (Pers.) Pouzar) spreads after unfavourable winters, usually on less hardy cultivars. In Latvia it is considered as one of the most dangerous diseases, as it damages the whole tree, including wood.

Common fruit rot (caused by: *Monilinia fructigena* Honey) is widespread, especially in moist summers, in poorly managed orchards.

Plum pockets (caused by *Taphrina pruni* Tul.) is rare in Latvia, but is a potentially dangerous disease as it may completely destroy the yield.

## MAIN PLUM PESTS IN LATVIA

Plum sawfly (*Hoplocampa flava* L.; *Hoplocampa minuta* Christ.) is widely found in Latvia, which makes impossible successful plum growing without pesticides.

Plum codling moth (*Grapholita funebrana* Treitchke) was detected in the 1980s. In some years it can be very widespread and can destroy the entire yield.

Plum aphids (*Hyalopterus pruni* Geoffr.) are widely spread in Latvia and may cause significant damages, as in larger numbers can cause premature leaf drop and obstruction of new growth. They especially cause problems in organic or-

chards where insecticides are not used and if reeds are growing nearby.

Fruit-tree red spider mite (*Panonychus ulmi* C. L. Koch.) is widely spread in some years. There is lack of available acaricides and paraffine oil on the Latvian market.

## FRUIT QUALITY AND POST-HARVEST

For all new cultivars, including introduced cultivars, detailed quality assessment is done before their registration or recommendation for commercial plantations. The cultivars are tested for the following parameters: soluble solids, titrable acids, vitamin C, flesh firmness, as well as changes of firmness in common storage. Sensory analyses also are performed. It was found that the indices are influenced both by the cultivar and weather conditions of the year, and thus the parameters vary significantly between years. The fruit harvest date is especially important, i.e. the stage of fruit maturity during picking and analyses (Kaufmane *et al.*, 2010).

To examine the possibilities of prolonging plum storage time, trials were carried out at the Institute using 1-methylcyclopropene (1-MCP) — 12 h at 3 °C, 1-MCP in concentration 0.520 µl l<sup>-1</sup>. Effect of 1-MCP on physical and chemical indices and sensory quality of the plum (*Prunus domestica* L.) cultivars was evaluated. After four weeks of storage, significant differences were found between cultivars. For some cultivars 1-MCP treatment gave a positive effect on fresh weight and flesh firmness losses, as well as on preservation of colour, taste and aroma. However, most cultivars fruits after 1-MCP treatment had reduced sweetness (based on the Hedonic scale evaluation). Significant differences of results were observed between years (Radenkovs *et al.*, 2015).

Recently, research was conducted on potential use of plum stones as a by-product. A large amount of hexaploid and diploid cultivars in the institute collection was examined. It was concluded that different parts of the stone contain fatty acids, tocopherols, tocotrienols and carotenoids, their content significantly differing between cultivars (Gornas *et al.*, 2015).

## FUTURE PROSPECTS

Although at present the scale of plum growing in Latvia is small, the future prospects are rather good, because:

- In recent years, the area of commercial plantations (integrated and biological) has increased;
- The variety available has increased — new, better cultivars recommended by the Institute of Horticulture have been planted;
- Growing technologies have changed and more attention is paid to fruit quality (in some commercial orchards plantations were established with modern tree support systems — espaliers);

- Consumers more often choose local fruits;
- Processing enterprises have developed, which look for new ways of plum products — puree for children "Rūdofls", dried and candied plums, low-fat ice creams, etc.

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## PLŪMJU IZPĒTE UN AUDZĒŠANA LATVIJĀ

Latvijā plūmes komerciāli audzētas jau pagājušajā gadsimtā. Sevišķi stādījumi paplašinājās 20. gs. 20.–30. gados. Šajā laikā introducēja daudzas plūmju šķirnes, sevišķi no Rietumeiropas. Pēc 1939./40., 1941./42., 1955./56., 1978./79. gada barga sala ziemām plūmju stādījumi ievērojami samazinājās, galvenokārt pietiekami ziemcietīgu šķirņu trūkuma dēļ. Tāpēc plūmju sortimenta paplašināšanai sāka ieviest Krievijā, Baltkrievijā un Igaunijā selekcionētas šķirnes. No vecajām šķirnēm aktualitāti nav zaudējusi 'Latvijas Dzeltēnā Olplūme'. Tā kādreiz bija ļoti ražīga, izcēlās ar augstu ziemcietību un labu augļu kvalitāti. Diemžēl pēdējos gados kokaudzētāvās savairojušies šīs šķirnes ziemcietīgāki, bet mazražīgi kloni ar neapmierinošu augļu kvalitāti. Tā kā Latvijas patērētāji iecienījuši dzeltēnās plūmes, šobrīd norit darbs pie ražīgāko klonu atlases no veciem piemājas dārzkiem un stādījumiem un to pavairošanas. 20. gadsimta vidū Latvijā sākās aktīva plūmju selekcija, krustojot izturīgākus genotipus ar augstas kvalitātes donoriem. Šī perioda šķirnes 'Lāse' un 'Minjona' vēl joprojām tiek audzētas. Kopš 20. gs. 80. gadiem selekcijas darbs turpinās Dārzkopības institūtā. Krustojumi tika veikti galvenokārt ar heksaploīdajām plūmēm ar mērķi iegūt lielaugļu šķirnes ar labu garšu, kas ienākas dažādos laikos, īpaši koncentrējoties uz agrinām un vidēji vēlām šķirnēm. Jaunās institūtā selekcionētās šķirnes 'Sonora', 'Ance', 'Adelyn' izceļas ar labu augļu kvalitāti un ražību. Pilnražas gados raža ir 15–20 kg, atsevišķos gados — pat līdz 70 kg no koka.

Latvijā izplatītākais plūmju potcelms ir Kaukāza plūmes *Prunus cerasifera* Ehrh. ssp. *divaricata* C. K. Schneid.) sēklāudzis, kas ir izturīgāki par Eiropā izmantoto ķiršveida plūmi. Tiem ir laba saderība ar lielāko daļu šķirņu, izņemot renklodes, koki labi aug dažādās augsnes un ir izturīgi pret kaitēkļiem un slimībām. Trūkums ir garais veģetācijas periods, tāpēc aizkavējas uzpotēto šķirņu nobriešana, un tās var ciest salā; šie potcelmi veido daudz atvašu ap stumbru, īpaši, ja šķirnei ir nesaderība ar potcelmu. Dārzkopības institūtā ir izdalīts sēklāudzis (*Prunus cerasifera* un *P. salicina* ssp. *ussuriensis* hibrīds) ar augstu salcietību, kas nedaudz samazina koka augumu. Izmēģinājumi ar vairākiem Rietumeiropā un Krievijā selekcionētiem potcelmiem nav devuši pozitīvus rezultātus un ražošanā nav ieviesti. Šobrīd Dobeles ierīkots jauns izmēģinājums ar vairākām šķirnēm uz *Wangenheims* potcelma, kā arī uz maza auguma potcelmiem VVA-1, Weiwa, S766 and M633.



Plūmju komercaudzēšanas apjomi Latvijā ir salīdzinoši nelieli; platību ziņā plūmes ieņem pēdējo vietu starp augļu kokiem. Pārsvarā tās tiek audzētas svaigam patēriņam, nedaudz — ievārījumiem, jogurtu un saldējumu piedevām. Pieprasījums pēc plūmēm Latvijā ir, bet lielveikalos vietējie augļi praktiski nav pieejami. Izaudzētās plūmes tiek realizētas mazākos veikalos, tirgū vai uz vietas pie audzētājiem. To lielā mērā nosaka klimatiskie apstākļi, jo vidēji ik pēc pieciem gadiem ziemā temperatūra pazeminās līdz  $-30^{\circ}\text{C}$  un zemāk. Līdz ar to šobrīd tiek audzēts ierobežots šķirņu skaits. Komerciāli tiek audzētas apmēram 20 šķirnes, bet sešas populārākas šķirnes veido 69% no kopējās plūmju stādījumu platības. Pēdējos gados paplašinās Dārzkopības institūtā selekcionēto šķirņu, sevišķi agrīnās šķirnes 'Ance', platības.