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SAMMENDRAG/SUMMARY:

Nibio Ullensvang har i perioden 2010-2016 gjennomført rettleiingsprøving av samla 14 sortar og seleksjonar av søtkirsebær frå foredlingsprogrammet ved forskingsstasjonen Summerland i Canada.

Føremålet var å skaffa norske fruktdyrkarar sortar som gjev stor avling med kvalitetsfrukt og er tilpassa det norske klimaet. Sortane vart poda på den svaktveksande grunnstamma Gisela 5 og vart planta i ein plasttunnel. Pomologiske karakterar og fruktkvalitet vart vurderte og detaljert informasjon om dei ulike sortane er gjeve i denne rapporten. Sorten Starblush og seleksjonen SPC 108 er tilrådd for dyrking under norske tilhøve i tillegg til hovudsorten Lapins. Seleksjonen SPC 107 høver godt i småhagar.

In total fourteen cherry cultivars and advanced selections released by the Pacific Agri-Food Research Centre (PARC-Summerland), Agriculture and Agri-Food Canada were tested at NIBIO Ullensvang during 2010 – 2016. The scions were grafted on the dwarfing Gisela 5 rootstock and planted in high tunnels. Main phenological, vegetative growth and productivity characteristics and fruit quality parameters were evaluated and detailed information about the different cultivars and selections are presented. After comprehensive studies the cultivars SPC 108 and Starblush are recommended for

commercial fruit growing in Norway in addition to the main cultivar Lapins. SPC 107 is recommended for home gardens.

LAND/COUNTRY:	Norway
FYLKE/COUNTY:	Vestland
KOMMUNE/MUNICIPALITY:	Ullensvang
STED/LOKALITET:	Lofthus

GODKJENT /APPROVED	**PROSJEKTLEDER /PROJECT LEADER**
Inger Martinussen	Mekjell Meland
NAVN/NAME	**NAVN/NAME**

Preface

Norway has no breeding program in sweet cherries (*Prunus avium* L.). However, since 1959 a large number of different cultivars and selections have been tested from several breeding programs in Europe, USA and Canada. The testing has been continuously since the start and the cultivars used for commercial production have been totally renewed. Cultivars producing high quality fruit that ripen from mid July and throughout August) and that are suitable to grow in high-density production systems are the main objectives for this evaluation.

Key characteristics of totally fourteen Canadien cultivars/selections are described in this paper and the field and lab work are done at Nibio Ullensvang.

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Lofthus, 05.10.20

Mekjell Meland

Content

1 Introduction

World cherry production in 2019 is totally around 3.6 million tonnes. Turkey, USA, Chile and China are the largest sweet cherry producing countries (Donoso et al., 2019; Lang, 2019; https://www.freshplaza.com/article/9149328/world-cherry-production-will-decrease-to-3-6-million-tons/). During the last decade annual increase of cherry production and areas planted with cherries is far in front of all others horticultural crops. To keep such rapid growth a right combination of consumers demand, intensification of growing technologies and creation of new cultivars should be maintained.

There are several active cherry breeding programs in Europe and North America with a long history and dozens of released cultivars. Recently new breeding programs have been started in the countries where cherry production takes important place in commercial horticulture like Chile, China and Spain. (Queero – Garcia et al., 2017; Balas et al., 2019). Breeding programs have focus on tree performance, fruit quality traits, resistance to various biotic and abiotic factors and adaptiveness to the local growing conditions (Kappel & Sholberg, 2008).

Summerland cherry cultivars are known worldwide. The breeding program at the Pacific Agri-Food Research Centre, Summerland, Canada (PARC-Summerland) started in 1936. First released cultivars were 'Van' in 1944, followed by 'Summit', 'Lapins', and 'Sweetheart'. These cultivars are now grown in all main cherry producing countries (Kappel et al., 2008). Cultivars from the next generations of breeding program as 'Santina', 'Celeste', 'Cristalina', 'Skeena', 'Starblush' and 'Symphony' are commercially important too (Kappel et al., 2002; Hampson et al., 2013; Hampson et al., 2014). Some sources claim that 80% of world cherries were bred in Summerland (https://globalnews.ca/news/3560979/eighty-per-cent-of-the-worlds-cherries-originate-in-summerland/).

The aim of this study was to evaluate cherry cultivars and advanced selections released by the PARC-Summerland, to determine their adaptiveness to Norwegian growing conditions and to select possible candidates for commercial growing.

2 Materials and Methods

This cherry cultivar trial was performed at the experimental farm at NIBIO Ullensvang during 2010 – 2016. In total fourteen cherry cultivars and advanced selections released by the Pacific Agri-Food Research Centre (PARC-Summerland), Agriculture and Agri-Food Canada at Summerland were tested (Table 1). The cultivar Lapins served as control. Planting material was grafted on the dwarfing Gisela 5 rootstock and planted as one year old whips. The orchard was planted in spring 2010 in a high tunnel production system. Planting distance was 4 x 1.5 m. Each cultivar was replicated eight times with one tree per plot.

High tunnels, which are accessible to tractors, are constructed of steel bows, attached to metal posts and covered with greenhouse–grade polyethylene. Gutters were used in between tunnel bows to channel runoff rainwater away from the orchard. Beehives were installed outside the tunnels. Orchard floor management consisted of frequent mowing of the interrows and a 1 m wide herbicide strip was maintained in the intra-row. All trees received the same amount of fertilizers based on soil and leaf analysis. The trees were fed by an external drip irrigation system geared to provide nutrients through fertigation. The bays installed were 8.5 m wide x 70 m long, with legs 2.5 m in height. The tunnel was covered before bloom and covers were only removed when harvest was completed (beginning of September).

Trees were trained as free spindle. Pruning was performed in early spring at the dormant stage.

The phenological stages (start of bloom period, 20% of flowers open, full bloom, 80% of flowers open, and harvest dates were assessed every year.

Flowering abundance was evaluated visually in 1-9 scale, where 1 – no flowers, 9 – the highest possible number of flowers.

Increase in trunk growth was assessed annually by measurement of trunk diameter at 25 cm above middle of the graft union of the trees in autumn. Trunk diameter (d) was used to calculate trunk cross sectional area (TCSA) using the formula $TSCA = \pi*(d/2)^2$

The yield (kg/tree) was measured every year and accumulated yield for trial period is presented. Cumulative tree efficiency (kg cm^{-2} TCSA) was calculated dividing accumulated yield by TSCA in 2016.

Average fruit weight (g) was calculated based on 50 fruits sample per cultivar and year.

Fruit quality characteristics were determined on samples of 50 randomly collected fruits per tree.

Fruit firmness (N cm^2) was measured by fruit texture digital measurer Durofel® 25 (Copa-Technology CTIFL, France) using standard probe 0,25 mm in 2011-2013 and by FirmTech instrument (Bioworks, Stillwater, US) in 2014-2016. Soluble solid content (%) was measured by Atago® Pallete Digital refractometer PR-101 (Atago®, Tokyo, Japan). Fruit taste was evaluated by trained panellists and assessed in 9 scale score, where 1 – uneatable, 9 – excellent taste.

Number of trees lost during the period 2011-2018 was recorded annually and causes of their death were defined.

Data was analysed by general analysis of variance (ANOVA) for randomised complete block designs using the statistical program Minitab® 16 statistical software (Minitab Ltd., UK). All main data is presented as an average of six years.

3 Results and Discussions

The cultivar testing trial included 14 cultivars and advanced selections recently bred or selected at PARC-Summerland, Canada. Testing of sweet cherry cultivars in Norway has been carried out at Ullensvang Research Centre already since 1959. Cultivars of Canadian origin were included in these trials constantly (Meland and Frøynes, 2008). Other large Summerland cherry trials in Scandinavia was performed by Christensen (1997) in Denmark where 20 cultivars and advanced selections were included.

Tested cultivars derived from different crossing combinations and have different S locus (Table 1). Multi-allelic *S* locus determine self-incompatibility or incompatibility between cultivars in cherry (*Prunus avium* L.). Cultivars with the same *S* genotype are cross-incompatible. It is very important for commercial growing, to plant cultivars from cross-compatibility groups (Wiersma et al., 2001; Sonneveld et al., 2001; Schuster et al., 2007; Schuster 2012) or to breed self compatible cultivars. Most of tested cultivars and advanced selections are self compatible, and thus ensure annual and large yield (Table 1). For some recent selections information is not available due to decision of the breeder.

Table 1. Compatibility groups and parentage of tested Summerland sweet cherry cultivars and advanced selections.

Cultivar	S – allele profile	Incompatibility group	Parents
Lapins (control)	S_1 $S_{4'}$	Self compatible	Van x Stella
Sandra Rose	S_3 $S_{4'}$	Self compatible	2C-61-18 x Sunburst
Santina	S_1 $S_{4'}$	Self compatible	Stella x Summit
Satin	S_1 S_3	II	Lapins x 2N-39-05
Sofia (SPC 106)	S_2 $S_{4'}$	Self compatible	OSC#6 x2S-28-39
Starblush (SPC 207)	S_3 $S_{4'}$	Self compatible	Stella x 2S-84-10
Suite Note (SPC 136)	S_2 S_4	XIII	2S-36-36 x Summit
Sumbola	S_1 S_3	II	Star x 2S-41-27
SPC 107	S_3 $S_{4'}$	Self compatible	2N-63-20 x Stella
SPC 108	S_1 $S_{4'}$	Self compatible	2N-41-09 x 2N-37-14
SPC 210	Not known	not tested	no breeder's info
SPC 221	Not known	not tested	2C-61-18 x Summer Jewel
SPC 263	Not known	not tested	no breeder's info
SPC 335	S_1 S_3	not tested	no breeder's info
23155	Not known	not tested	no breeder's info

The average dates of first flower and full bloom differed between cultivars in 5 days in average for the tested period (Table 2). The earliest flowering period was recorded for Satin, SPC 210 and SPC 335, late flowering period – for Santina and SPC 107. The period from the first opened flowers until full bloom of all tested cultivars and selections lasted 3-4 days. Time of full bloom depended on year conditions. The earliest flowering was recorded in 2014, when the average time of all cultivars was April 25. Almost a month later flowering was recorded in 2013, when the average time of full bloom was May 22. Differences between the earliest and the latest flowering cultivars also were affected by year weather conditions and varied between 3-4 days in most of trial years up to 10 days in 2015. Despite of mentioned differences between the years tendencies of full bloom time of tested cultivars remain the same.

Amount of flowers significantly varied in the tested group of cultivars and advanced selections. Sofia and Sumbola distinguished by very abundant flowering, while Santina, Suite Note and SPC 221 had very modest flowering.

The fruit harvest time varied by 3 weeks in the tested group. Santina fruits ripened 2 weeks earlier than Lapins. Another two cultivars Suite Note and SPC 221 were harvested 12 -10 days before Lapins. SPC 263 was the latest and its fruit harvest was delayed by 1 week comparing to the control (Fig. 1). The average harvest time was significantly affected by growing season conditions. The earliest harvest was in 2014, on the average in July 20, and the latest in 2015, on the average in August 14. Despite of that a little variation of harvest time between early ripening and late cultivars was recorded – 19 – 22 days. Analyzing cultivars separately during the 6 year trial period the lowest variation of harvest time (17-18 days) was recorded for SPC 210 and Sofia, and the largest (30-33 days) – for SPC 108, SPC 221 and Satin. Despite of mentioned differences between the years, the order of harvest time between tested cultivars remain the same.

Table 2. Dates of first bloom,full bloom (80% of flowers open) and amounts of flowering, average of 2012-2016, and tree survival by the end of the testing (2018) of Summerland sweet cherry cultivars and advanced selections.

Cultivar	Bloom start, date	Full bloom, date	Amount of flowers (1-9)	Tree loss 2010-2018
Lapins (control)	05-May	08-May	7.1	0
Sandra Rose	07-May	10-May	6.9	0
Santina	07-May	11-May	5.3	5
Satin	02-May	06-May	6.8	3 (of 4)
Sofia (SPS 106)	06-May	10-May	7.6	3
Starblush (SPS 207)	05-May	08-May	6	1
Suite Note (SPS 136)	07-May	10-May	5.5	0
Sumbola	04-May	07-May	7.5	4
SPC 107	07-May	11-May	6.4	0
SPC 108	04-May	08-May	5.9	2
SPC 210	03-May	06-May	7.2	0
SPC 221	04-May	08-May	5.5	4
SPC 263	04-May	08-May	6.9	0
SPC 335	03-May	07-May	6.5	8
23155	05-May	09-May	7	0

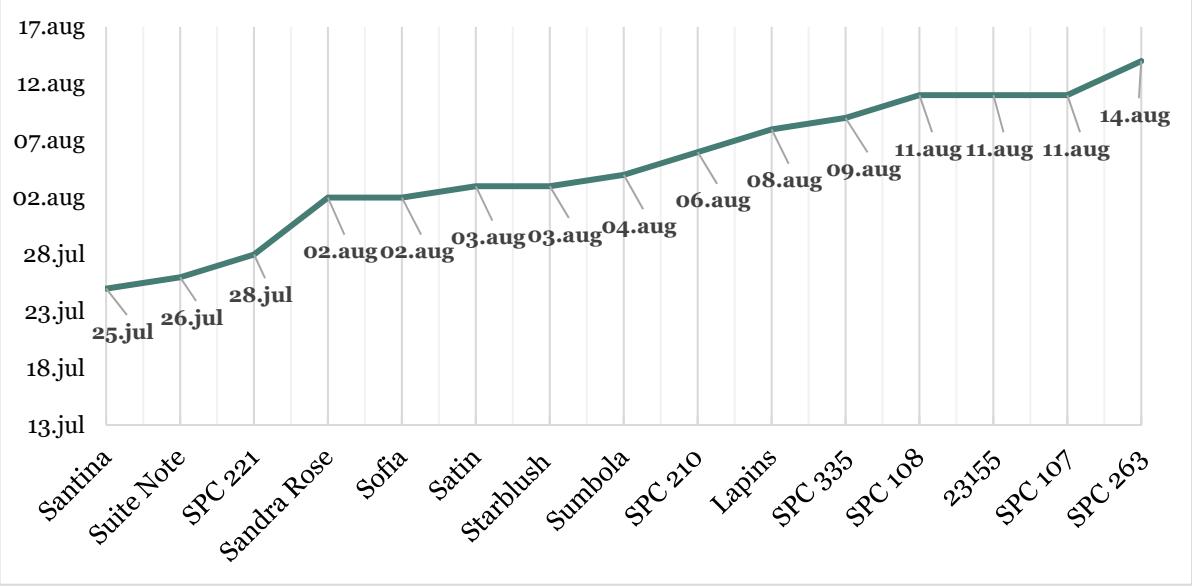


Figure 1. Average harvest date of tested Summerland sweet cherry cultivars and advanced selections, 2013 – 2016

According to ripening time tested cultivars and advanced selection can be sorted into following groups:

Medium: Santina, Suite Note, SPC 221, Satin, Sofia and Sandra Rose

Late: Starblush, Sumbola, SPC 210, SPC 335, Lapins, SPC 108 and SPC 107

Very late: 23155 and SPC 263

The very first cherry tree decline symptoms appeared in 2015 in the 6th year after the planting. Weak trees of SPC 335 and SPC 221 were found. By the end of the trial very high tree mortality of SPC 335

cherry trees was recorded (Table 2). All of eight planted trees were dead or very week. Half and more of Satin, SPC 221, Sumbola and Santina trees were lost or were very weak after 8 years after planting, probably due to scion – rootstock incompatibility.

Some of tested cultivars started to yield already in the second year after planting. SPC 108 and SPC 107 were the most precocious, while SPC 221 started to bear fruits only in the 4th year after planting (data is not presented).

Orchard profitability studies in USA showed that cherry production costs are evened when the yield reaches 14 t/ha (Long at al., 2019). According to this planting scheme minimum yield should be 8,4 kg/tree. Such and higher yields were harvested from SPC 107 starting from the 4th year of experiment when cherry trees reached the projected space. Other cultivars Sumbola, Starblush and SPC 108 reached such yield only in the 7th year of the experiment. These cultivars and advanced selections together with Lapins had significantly higher accumulated yields compared with other tested cultivars and selections (Table 3, Fig. 3). Satin and Suite Note were two low yielding cultivars.

Accumulated yield was not correlated with the average number of flowers (r = 0.24). Sofia had the highest flowering score (Table 2), but accumulated yield was low. At the same time flowering abundance of SPC 108 was low, meanwhile it had the highest accumulated yield in the tested group.

Table 3. Tree growth (TCSA), yield and cumulative efficiency of tested Summerland sweet cherry cultivars and advanced selections, 2011 – 2016

Cultivar	TCSA,[1] cm^2	Accumulated yield, kg/tree	Cumulative yield efficiency
Lapins	37.7 bcd	26.80 ab	0.71 bc
Sandra Rose	49.2 a	12.65 c	0.26 ef
Santina	45.2 ab	14.14 c	0.31 ef
Satin	21.6 fg	6.62 d	0.31 ef
Sofia (SPS 106)	24.4 fg	12.35 cd	0.51 de
Starblush (SPS 207)	37.6 bcd	25.83 ab	0.69 bc
Suite Note (SPS 136)	43.3 abc	7.38 cd	0.17 f
Sumbola	28.0 ef	23.17 b	0.83 ab
SPC 107	34.5 cde	30.43 a	0.88 a
SPC 108	35.5 bcde	30.80 a	0.87 a
SPC 210	18.0 g	10.10 cd	0.56 cd
SPC 221	30.6 def	9.38 cd	0.31 ef
SPC 263	24.1 fg	10.66 cd	0.44 ef
SPC 335	24.2 fg	11.08 cd	0.46 ef
23155	37.2 bcde	9.98 cd	0.27 ef
Average	32.7	16.09	0.50

Values within a column that do no share the same letter are significantly different

[1]TCSA= Tree trunk sectional area

Tree trunk sectional area (TCSA) measured at the end of the trial revealed the differences in the cultivar vigour. All the tested trees were propagated on the same dwarfing Gisela 5 rootstock, but their vegetative growth differed almost 3 times (Table 3). Differences in growth vigour between cultivars on Gisela 5 rootstock were found in other studies too (Gjamovski et al., 2016). In this trial SPC 210, Satin, SPC 263, SPC 335 and Sofia were the most dwarfing cultivars, and Sandra Rose, Santina and Suite Note were the most vigorous ones.

Usually, as it is confirmed with other fruit crops, the more dwarf trees the higher yield efficiency they exhibit. However, this was not the case with cherry cultivars tested in this trial. Cumulative yield efficiency was directly correlated with accumulated yield (r = 0.89) but no correlation was found with the cherry tree vigour (r = - 0.2) (Fig.2). Top five cultivars and advanced selections with the highest yield SPC 108, SPC 107, Lapins, Starblush and Sumbola at the same time were top five cultivars that had the highest cumulative yield efficiency (0.69 – 0.88 kg/TCSA). Vegetative growth of all these cultivars fell only in the middle of tested group. Low bearing, and one of the most vigorously growing Suite Note, demonstrated the lowest cumulative efficiency. Sandra Rose, 23155, Satin, SPC 221 and Santina lacked high efficiency too.

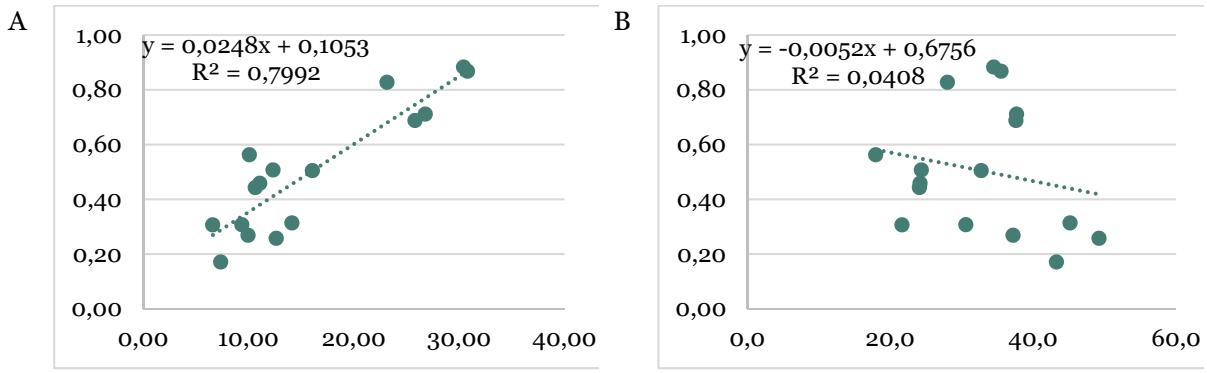
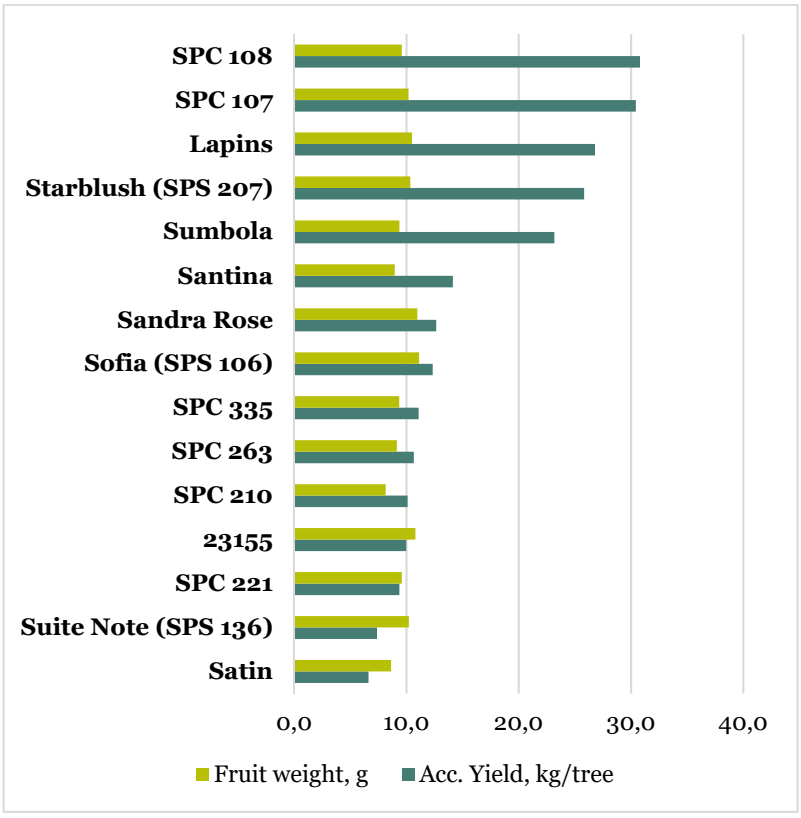


Figure 2. Correlation between cumulative yield efficiency and accumulated yield (A) and cumulative yield efficiency and tree trunk cross sectional area (B).



Fiure 3. Accumulated cherry yield (kg/tree) and average fruit weight (g), 2011-2016. Cultivars sorted by accumulated yield in ascendant order.

It is well known that rootstock scion combination plays an important role on fruit quality parameters, tree growth, precocity and productivity (Gonçalves et al., 2006; Lanauskas et al., 2012). Not all rootstocks suit the best for certain cultivars. This trial revealed that for some tested cultivars and selections having inherent low vigour, the rootstock Gisela 5 could be a too dwarfing one. In order to overcome this problem cultivars and selections SPC 210 and Satin and particularly SPC 263, SPC 335 and Sofia should be tested on more vigorous rootstocks or according to their growth parameters should be planted more dense.

The main fruit quality characteristics are fruit weight, size and firmness. As fruits are sold in the fresh market, large fruits are the consumer preference (Whiting et al., 2006; Ladner et al., 2008). Cultivars Sofia and Sandra Rose had the largest fruits over 11 g, whereas the smallest fruits 8,2 – 8,6 g were harvested from SPC 210 and Satin trees (Table 5). Average fruit weight was not correlated with accumulated yield. Fruit weight of low yielding Satin, SPC 210, or SPC 263 was less or similar to high yielding SPC 108, SPC 107, Lapins and others (Fig 2).

When fruits were graded according to their diameter, differences between cultivars were significant. Ninety and more percent of SPC 221, SPC 335 and Sofia fruits were larger than 28 mm (Table 4). Additionally to them, Sumbola, Satin and Lapins also had large fruits and all of them were not less than 26 mm. SPC 210 and SPC 108 had the lowest percentage of 28 mm + size fruits, 2 and 10 % respectively. SPC 210 and Sandra Rose had the highest share of low size (22 - 24 mm and 24 - 26 mm) fruits, 58 and 40 % respectively. Evaluating fruit average weight in groups of certain fruit sizes, variation between cultivars were only by 10 – 15% and was not significant. Somewhat lower values of SPC 210 in the group of 28 mm + or higher values of Sumbola in the group of 24 - 26 mm can be explained that too few berries belong to this group.

Table 4. Distribution of fruit size groups (%) and average fruit weight, g of Summerland sweet cherry cultivars and advanced selections

Cultivar	Size group							
	22 - 24 mm		24 - 26 mm		26 - 28 mm		28 mm +	
	%	g	%	g	%	g	%	g
Lapins (control)					24	9.8	76	12.0
Sandra Rose			40	8.9	42	11.1	18	12.1
Santina			4	8.0	38	9.9	58	11.7
Satin					20	10.1	80	12.8
Sofia (SPC 106)					10	10.3	90	12.7
Starblush (SPC 207)			4	7.4	14	9.8	82	12.7
Suite Note (SPC 136)			12	8.2	22	10.4	66	12.7
Sumbola					66	10.9	34	11.7
SPC 107			2	10.0	42	10.9	56	12.5
SPC 108	8	6.7	24	7.9	58	9.8	10	12.0
SPC 210	10	7.1	48	8.4	40	9.5	2	10.6
SPC 221					4	8.9	96	12.6
SPC 263	2	7.0	20	8.5	50	10.6	28	12.1
SPC 335					6	10.8	94	12.2
23155	2	6.9	26	8.1	38	9.8	34	11.4

Soluble solid content (SSC) in cherry fruits is highly correlated with fruit sugar content and in some extend with fruit flavour and consumer preference (Blažková et al., 2002; Crisosto et al., 2003). Selection SPC 335 fruits had significantly the highest SSC (Table 5). High SSC was recorded in Sumbola and SPC 210 fruits (>17%) and these were only two cultivars that did not differ significantly from SPC 335. Very low SSC was in Sofia and SPC 221 fruits.

Very high taste scores received Suite Note, SPC 263, Sofia and Starblush (7.4 - 7.8), while Satin and 23155 fruits got the lowest scores, respectively 5.1 and 5.5.

Table 5. Fruit quality parameters of Summerland sweet cherry cultivars and advanced selections (2014-2016).

Cultivar	Fruit weight, g	Soluble solid content, %	Firmness[1]	Firmness[2] g mm^{-1}	Taste scores, (1-9)	Fruit cracking [3]
Lapins (control)	10.5 ab	16.2 bc	61.1 e	247	5.8 cd	tolerant
Sandra Rose	11 a	15.9 cd	51.9 f	235 bcd	5.7 cd	susceptible
Santina	9 cd	16 cd	64.5 e	220 cd	6.6 bc	tolerant
Satin	8.6 de	16.1 bc	77.5 ab	269 abcd	5.1 d	tolerant
Sofia (SPS 106)	11.1 a	15.3 cd	81.2 a	279 ab	7.6 ab	susceptible
Starblush (SPS 207)	10.3 ab	16.6 b	61 e	242 bcd	7.4 ab	tolerant
Suite Note (SPS 136)	10.2 ab	15.5 cd	54.7 ef	200 d	7.8 a	tolerant
Sumbola	9.4 bc	17.5 ab	66.5 de	196 d	6.7 bc	tolerant
SPC 107	10.2 ab	16.6 b	70.5 cd	213 d	6.5 bc	susceptible
SPC 108	9.6 abc	15.9 cd	70.2 cd	225 bcd	7.2 ab	tolerant
SPC 210	8.2 e	17.1 ab	81.4 a	255 abcd	6.7 bc	tolerant
SPC 221	9.6 abc	15.0 d	75.3 bc	273 abc	5.9 cd	tolerant
SPC 263	9.1 bcd	16.5 b	78.7 ab	255 abcd	7.7 a	susceptible
SPC 335	9.4 bc	18.6 a	84.5 a	281 a	6.5 bc	susceptible
23155	10.8 ab	16.4 b	77.4 abc	319 a	5.5 cd	susceptible
Average	9.8	16.3	70.4	247.3	6.6	

Note. Means in the column marked by the same letter did not differ significantly
[1]Firmness: measured with Durofel penetrometer (France)
[2]Firmness: measured with FirmTech instrument (US)
[3]Fruit cracking based on field observation??

Fruit firmness is important character mainly correlated with better marketing and less postharvest losses (Romano, 2006). Cherry fruit firmness was measured with two devices Durofel and FirmTech. Both instruments are not destructive. These devices measure what the pickers or consumers will feel when they gently squeeze the fruit. Devices squeeze the fruit to determine the firmness. The Firmtech instrument measure the rate at which the force (grams) increases per unit of deformation (mm) and define it as firmness (grams mm^{1}). The results of Durofel measurements are not expressed in units of strength but like an index. Both instruments were used in different years, some differences in fruit firmness and some differences in cultivar order according fruit firmness could be caused not only by device but also by growing conditions at particular seasons.

Fruits of most of tested cultivars measured by Durofel device were significantly firmer than the control cultivar Lapins. Especially firm fruits were measured from the SPC 335, SPC 210 and Sofia cultivars (Table 5). Only cultivars Suite Note and Sandra Rose had lower fruit firmness, though significant difference was only with the latter one. Some differences in cultivar order according to their fruit firmness occurred when FirmTech device was used. Significantly firmer were fruits were measured

form the trees of selections 23155, SPC 335, Sofia and some others. Cultivars Suite Note, Sumbola and selection SPC 107 had the softest fruits. High fruit firmness of SPC 335 and Sofia was validated by both devices, as well as low fruit firmness of Suite Note.

Fruit cracking is one the main problems in cherry cultivation and it was never been solved completely. Growing of cherries under plastic covers or in high tunnels remains the first option to reduce fruit cracking (Børve and Meland 1998; Børve et al., 2008; Meland et al., 2017; Mika et al., 2019). Some fertilizers could have a positive effect but not constantly since it depends on abundance of precipitations or on amount of water absorbed through roots (Vercammen et al., 2008). In this trial, relatively high fruit cracking of some cultivars under plastic cover could be influenced by excessive irrigation what was proved in earlier performed trials (Meland et al., 2014; Suran et al., 2019). However, almost half of tested cultivars and advanced selections had fruits with very low sensitivity to cracking (Table 5).

Combining all main cherry tree and fruit quality parameters as accumulated yield, cumulative efficiency, flowering abundance, fruit weight, firmness, soluble solid content and fruit taste, the best cultivars and advanced selections are indicated (Fig. 4). Larger marked area in the figure distinguishes better overall score of SPC 108, SPC 107, Lapins, Starblush and Sumbola cultivars.

Figure 4. Combined evaluation of sweet cherry cultivars and advanced selections, where 1 – accumulated yield, 2 – fruit weight, 3 – soluble solid content, 4 – flowering, 5 – taste, 6 – fruit firmness (/10); 7 – cumulative efficiency (x 10). The larger marked area the better overall score.

Cultivar descriptions

SANDRA ROSE	
Parents	2C-61-18 x Sunburst
S genotype	S_3 S_4,
Compatibility	Self compatible
Flowering	Medium to abundant, 2 days after Lapins.
Ripening time	6 days after Lapins.
Precocity	Comes slowly into production.
Yield	Low.
Fruit	A bit uneven fruit weight, but mostly very high - 11 g., some years - 8 g. Fruit has not so nice appearance with long brownish stem and round fruit shape. Fruit skin is not so glossy as other cultivars. Most years medium taste, low acids contents. Fruit firmness lower than comparable cultivars ripening at the same time. Excessive irrigation can cause lower flesh firmness. Fruit needs to be dark to achieve acceptable taste. Round shaped with a bit tough skin and long, green, tick stem. Uneven ripening. Stem can get brownish. The stem can be a bit tough attached to the branch.
Fruit cracking	Susceptible.
Tree growth	Very vigorous.
Tree survival	No tree losses by the end of the testing period.
Conclusion	Sandra Rose has no commercial value under the growing conditions tested due to low yield.

SANTINA	
Parents	Stella x Summit
S genotype	S_1 S_4,
Compatibility	Self compatible
Flowering	Low, 3 days after Lapins.
Ripening time	14 days before Lapins.
Precocity	Comes slowly into production.
Yield	Low.
Fruit	Large, but uneven fruits. Average fruit weight 9 g. Fruit has nice appearance but can sometimes show brownish stems. Moderate, good taste. Can lack some acid component. Medium fruit firmness. Dark red colour. Heart shaped fruit. Can have a rather long harvest window.
Fruit cracking	Little.
Tree growth	Very vigorous, develop a lot of bare wood.
Tree survival	Five of eight trees had died by the end of the testing period.
Conclusion	Santina has no commercial value under the growing conditions tested due to low yield and low tree survival.

SATIN	
Parents	Lapins x 2N-39-05
S genotype	S_1 S_3
Compatibility	Incompatible. II group
Flowering	Medium to abundant, 2 days before Lapins.
Ripening time	5 days before Lapins.
Precocity	Comes slowly into production.
Yield	Very low.
Fruit	Smaller fruits than comparable cultivars ripening at the same time. Average fruit weight 8.6 g. Fruit can from time to time get a russet surface. Taste is medium. Medium fruit firmness. Very dark red colour. Heart shaped fruit.
Fruit cracking	Little
Tree growth	Dwarf.
Tree survival	Most trees are weak and unhealthy. Tree decline symptoms on three out of four trees.
Conclusion	Satin has no commercial value under the growing conditions tested due to low yield, medium fruit quality and low tree survival.

SOFIA® **(SPC 106)**	
Parents	OSC#6 x2S-28-39
S genotype	S_2 S_4,
Compatibility	Self compatible
Flowering	Abundant, 2 days after Lapins.
Ripening time	4 days before Lapins.
Precocity	Comes slowly into production.
Yield	Low.
Fruit	Large fruits. Average fruit weight 11.1 g. Fruit has nice appearance. Tasty, crisp and firm fruits. Mottled red coloured fruit. Sometimes observed loose attachment between the fruit and stem at harvest time.
Fruit cracking	Susceptible
Tree growth	Dwarf, weeping.
Tree survival	Tree decline symptoms on three out of eight trees by the end of the testing period.
Conclusion	Sofia has fruits with nice appearance, very good taste and very crisp and firm fruits. Sofia should be tested on more vigorous rootstock due to low scion vigour

STARBLUSH® (SPC 207)	
Parents	Stella x 2S-84-10
S genotype	S_3 S_4'
Compatibility	Self compatible
Flowering	Medium, flowering time as Lapins.
Ripening time	5 days before Lapins.
Precocity	Comes fast into cropping mode.
Yield	High, partly over cropping
Fruit	Fruit weights high, but reduced weights by over cropping. Average fruit weight 10.3 g. Fruit has nice blushed appearance and quite glossy fruit. Skin can be a bit tough. Most years little bruising. Good to very good taste quality. Moderate to high fruit firmness. Over cropping can reduce firmness. Yellow ground colour and a nice mottled blush on the fruit. Amount of blush can differ by years and within the tree. Round shaped fruit with a medium long stem. Little fruit rot is observed.
Fruit cracking	Little.
Tree growth	Vigorous
Tree survival	One of eight trees were dead by the end of the testing period.
Conclusion	Starblush is recommended for commercial fruit production

SUITE NOTE® (SPC 136)	
Parents	2S-36-36 x Summit
S genotype	S_2 S_4
Compatibility	Incompatible. XIII group
Flowering	Low, 2 days after Lapins.
Ripening time	13 days before Lapins.
Precocity	Comes slowly into production.
Yield	Low.
Fruit	Large fruit weight for this ripening period. Average fruit weight 10.2 g. Fruit has nice, glossy appearance. Good to very good taste with a hint of bitterness. Fruit firmness lower than comparable cultivars ripening at the same time. Mottled dark red colour. Fruits can be damaged by fruit rot. Well ripe fruit can get loose attachment between the fruit and stem.
Fruit cracking	Little.
Tree growth	Vigorous.
Tree survival	No tree losses by the end of the testing period, but two of eight trees had decline symptoms.
Conclusion	Suite Note has no commercial value under the growing conditions tested due to low yield and low fruit firmness.

SUMBOLA	
Parents	Star x 2S-41-27
S genotype	S_1 S_3
Compatibility	Incompatible. II group
Flowering	Abundant, 1 day before Lapins.
Ripening time	4 days before Lapins.
Precocity	Comes slowly into production.
Yield	High
Fruit	Uneven fruit weights and mostly a relatively small fruits comparable to cultivars ripening at the same time. Average fruit weight 9.4 g. Fruit has nice appearance. Some years good taste, others moderate. Fruits loose taste quite fast after harvest. Fruit firmness lower than comparable cultivars ripening at the same time. Excessive irrigation can cause lower flesh firmness. Dark red colour, a bit mottled coloured fruit**.** Round shaped with a bit tough skin and long, green, tick stem. Sometimes observed loose attachment between the fruit and stem at harvest time.
Fruit cracking	Little
Tree growth	Moderate.
Tree survival	Four of eight trees had tree decline by the end of the testing period.
Conclusion	Sumbola has no commercial value under the growing conditions tested due to moderate fruit quality and high tree losses.

SPC 107	
Parents	2N-63-20 x Stella
S genotype	S_3 S_4,
Compatibility	Self compatible
Flowering	Abundant, 3 days after Lapins.
Ripening time	3 days after Lapins.
Precocity	Comes fast into production.
Yield	Very high, partly over cropping.
Fruit	Large fruit size if normal crop, reduced fruit size if over cropping. Average fruit weight 10.2 g. Fruit has nice blushed appearance and quite glossy fruit. Most years little bruising, some years more. Skin seems to be tough. Good fruit taste, but over cropping reduces taste quality. The fruits are quit firm when trees have normal crops and reduced when over cropping. Yellow ground colour and a nice mottled blush on the fruit. Amount of blush can differ by years and within the tree. Kidney shaped fruit with a long stem. Little fruit rot is observed.
Fruit cracking	Susceptible
Tree growth	Medium vigorous.
Tree survival	No tree losses by the end of the testing period.
Conclusion	Despite several positive traits, other blushed cultivars have higher market potential with less fruit bruising. SPC 107 is recommended for home gardens

SPC 108	
Parents	2N-41-09 x 2N-37-14
S genotype	$S_1 S_4$,
Compatibility	Self compatible
Flowering	Moderate, same time as Lapins.
Ripening time	3 days after Lapins.
Precocity	Comes fast into production.
Yield	Very high, partly over cropping.
Fruit	Large fruit size if normal crop, reduced fruit size when over cropping. Average fruit weight 9.6 g. Fruit has nice appearance and good stem quality. Stores in cold store quit well. Not the most tasteful fruit, a bit too acid/-bitter. But with adequate yield amount and the right picking time, soluble solid content gets high enough and taste gets balanced and good. Fruit firmness is quite high. Dark red coloured fruit. Round shaped with a long stem. Not much fruit rot observed but can appear in dense clusters.
Fruit cracking	Little
Tree growth	Vigorous.
Tree survival	Two of eight trees were dying by the end of the testing period.
Conclusion	SPC 108 recommended for commercial growing

SPC 210	
Parents	Information not available
S genotype	Information not available
Compatibility	Information not available
Flowering	Abundant, 2 days before Lapins.
Ripening time	2 days before Lapins.
Precocity	Comes late into production.
Yield	Low
Fruit	Fruit weight lower than comparable cultivars ripening at the same time. Average fruit weight 8.2 g. Very good taste most years, accept in climatic unfavourable years like 2012 and 2015. Very firm fruit flesh. Nice mottled red-dark colour. Round shaped with medium long green stem.
Fruit cracking	Little
Tree growth	Dwarf, weeping, a bit tender trees, and bare wood
Tree survival	No tree losses by the end of the testing period.
Conclusion	SPC 210 has no commercial value under the growing conditions tested.

SPC 221	
Parents	**2C-61-18 x Summer Jewel**
S genotype	Information not available
Compatibility	Information not available
Flowering	Low, flowering time the same as Lapins.
Ripening time	11 days before Lapins.
Precocity	Comes slow into production.
Yield	Low.
Fruit	Large but uneven fruit weights. Average fruit weight 9.6 g. Fruit has nice, glossy appearance. Moderate, good taste when dark red colour. Quite good fruit firmness. Dark red colour. Kidney shaped fruit. Most fruits approaching maturity get loose attachment between the fruit and stem. It is therefore very hard to harvest the fruit without getting detached fruits.
Fruit cracking	Little.
Tree growth	Medium
Tree survival	Four of eight trees had died by the end of the testing period.
Conclusion	SPC 221 has no commercial value under the growing conditions tested due to low yield, moderate fruit quality and low tree survival.

SPC 263	
Parents	Information not available
S genotype	Information not available
Compatibility	Information not available
Flowering	Medium to abundant, flowering time the same as Lapins.
Ripening time	6 days after Lapins.
Precocity	Comes slow into production.
Yield	Low. Alternating.
Fruit	Uneven fruit weight and mostly too small. Average fruit weight 9.1 g. Fruit has nice, glossy appearance. Very good taste and firm fruits. Mottled, dark red colour. Kidney shaped with a short stem. Fruits can be considerable damaged by fruit rot, especially in the clusters.
Fruit cracking	Susceptible
Tree growth	Dwarf.
Tree survival	No tree losses by the end of the testing period.
Conclusion	SPC 263 has very tasteful quality fruits but, but trees exhibit some in-compatibility on rootstock Gisela 5 SPC 263 should be tested on more vigorous rootstocks than Gisela 5.

SPC 335	
Parents	Information not available
S genotype	Information not available
Compatibility	Information not available
Flowering	Abundant, 1 day before Lapins.
Ripening time	1 day after Lapins.
Precocity	Comes slow into production.
Yield	Low to medium
Fruit	Uneven fruit weights and mostly low to medium. Average fruit weight 9.4 g.
	Fruit has nice, glossy appearance. Some years good taste, sweet and tasteful, other years moderate taste with more bitterness. Very crisp and firm fruits. Dark red coloured fruit. Kidney shaped fruit with medium to short stem. Sometimes observed loose attachment between the fruit and stem at harvest time.
Fruit cracking	Suceptible
Tree growth	Dwarf. Many weak and unhealthy trees in the test plot, and a lot of bare wood, presumably due to incompatibility reactions to rootstock Gisela 5.
Tree survival	Two of eight trees were dead and six of eight had tre declining by the end of the test period.
Conclusion	SPC 335 has no commercial value under the growing conditions tested due to low yield, low fruit quality and low tree survival.

23155	
Parents	Information not available
S genotype	Information not available
Compatibility	Information not available
Flowering	Abundant, 1 day after Lapins.
Ripening time	3 days after of Lapins.
Precocity	Comes slow into production.
Yield	Low
Fruit	Large fruits. Average fruit weight 10.8 g. Fruit has nice appearance. Most years moderate taste and at bit too acid. Very firm fruit. Dark coloured fruit. Kidney shaped fruit with a short stem. Fruits easily get rot attack on the tree, even though distances between the fruit is quite long. The fruits have loose attachment between the fruit and stem, and stem attachment to the branch are tough. This causes problems to pick out ripe fruits without getting detached fruits.
Fruit cracking	Suceptible
Tree growth	Vigorous and can get a lot of bare wood.
Tree survival	No tree losses by the end of the testing period.
Conclusion	23155 has no commercial value under the growing conditions tested due to low yield, complicated harvest and low fruit quality.

LAPINS	
Parents	Van x Stella
S genotype	S1 S_4
Compatibility	Self compatible
Flowering	Abundant along with Van
Ripening time	Late, 11 days after Van
Precocity	Comes fast into production.
Yield	High. partly over cropping
Fruit	Fruit is flat round shaped, has dark red colour, is firm and quite big – the biggest 13,9 g and smallest 9 g. Fresh appearance with green, thick rather long stem. Taste is fairly good. Good harvest/marked quality: fruit well attached to the stem, can stand handling, grading machine treatment and transport.
Fruit cracking	Little in plastic tunnel, but can crack under excessive irrigation.
Tree growth	Moderate on rootstock Gisela 5.
Tree survival	No tree losses by the end of the testing period.
Conclusion	Lapins is the standard cultivar in the mid/late season in Norway, widely grown in most cherry production areas. Lapins is known for high cropping ability in a marked period with high demand for cherries. It is also used as a pollinizer tree for self sterile cultivars with early blooming time

Conclusions

After comprehensive studies of fourteen Summerland sweet cherry cultivars, and advanced selections, the cultivars SPC 108 and Starblush are recommended for commercial fruit production in addition to the main cultivar Lapins.

Despite high productivity and high overall evaluation Sumbola and SPC 107 are not recommended for commercial growing due to some negative fruit quality parameters or high tree losses for Sumbola.

SPC 107 is recommended for home gardens.

Selection SPC 263 had no tree losses and showed outstanding fruit quality parameters, but were not included into recommended cultivar list due to low productivity and stunted tree growth. SPC 263 should therefore be tested on more vigorous rootstocks than Gisela 5.
Also, Sofia showed outstanding fruit quality traits. In spite of high cracking ability and severe tree health problems, Sofia should be tested on a more vigorous rootstocks than Gisela 5.

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Cover: Flowering sweet cherry trees in a high plastic tunnel. Photo: Oddmund Frøynes

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