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Apple cultivar evaluation for commercial growing in Norway

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SAMMENDRAG/SUMMARY:

Nibio Ullensvang har i perioden 2008-2017 gjennomført rettleiingsprøving av samla 20 eple sorter og -seleksjonar. 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 M9. Pomologiske karakterar og fruktkvalitet vart vurderte og detaljert informasjon om dei ulike sortane er gjeve i denne rapporten. Sortane Rubinstep, Your Choice og Aroma 'Fagravoll' vert tilrådde til kommersiell frukt dyrking. Sorten Blyberg er tilrådd for småhagebruket medan sortane Lotos og Wellant bør prøvast vidare. På grunn av svak fruktkvalitet og sein modning er fylgjande sortar og utval ikkje tilrådde for dyrking under norske tilhøve: L II 3/05-09, Sonja, L II 1/08-09, NA 42-51, MA982 06059, Ritt Bjerregaard, Dalili Embassy, Initial, Gala Must, Topas, Greenstar og Kanzi.

In total twenty apple cultivars, and advanced selections, were tested at NIBIO Ullensvang during 2008 – 2017. 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 Rubinstep, Your Choice and Aroma 'Fagravoll' are recommended for commercial fruit production; cultivar Blyberg recommended for a small-scale production for road sale and amateurs gardens, and Creston recommended for processing purposes. Two cultivars Lotos and Wellant are recommended to test additionally in commercial scale. Due to low fruit quality parameters and/or lack of taste and fruit appearance and/or due to too late harvest following apple cultivars and advanced selections L II 3/05-09, Sonja, L II 1/08-09, NA 42-51,


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MA982 06059, Ritt Bjerregaard, Dalili Ambassy, Initial, Gala Must, Topas, Greenstar and Kanzi are not recommended to grow in Norway.

LAND/COUNTRY: Norway
FYLKE/COUNTY: Vestland
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STED/LOKALITET: Lofthus

GODKJENT /APPROVED

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Preface

NIBIO Ullensvang is responsible for the official fruit cultivar testing in apple, sweet cherry, plum and pear in Norway. The aim is to find cultivars adopted to Norwegian environmental conditions giving large and annual yields of high quality. Each year new cultivars are planted in field trials from breeding programs abroad or the Norwegian breeding program Graminor. Pomological characters and fruit quality assessments are evaluated for a period of 5-7 years.

In this report in total twenty apple cultivars and advanced selections are described for key characteristics. The field and lab work was done at NIBIO Ullensvang.

The project is funded by The Norwegian Ministry of Agriculture and Food.

Lofthus, 11.11.2020

Mekjell Meland

Content

- 1 Introduction..... 6
- 2 Materials and Methods 7
- 3 Results and Discussions 9
- Conclusions..... 42
- References..... 43

1 Introduction

In recent years, apple cultivar breeding has changed globally, there has been a rapid acceleration of introduction of new apple cultivars and new marketing strategies are adopted (Maas et al, 2010). Besides state supported institutions, there is increased release of new cultivars from private breeding programs or nursery cooperatives.

Increasing demand for healthier and safe food from the consumers side keeps high pressure on fruit and berry industry, which must find out ways of production of high quality fruits. One of the options is cultivation of scab resistant apple cultivars, that lead to the significant reduction of chemical treatments. Most of apple breeding programs in different countries are aimed to create disease resistant cultivars (Nybom et al., 2015). Though fruit research is leading to a better understanding of the mechanisms of resistance, unfortunately, the majority of scab resistant selections are still derived from *Malus floribunda* (Vf gene), which has broken-down in many regions of production (Brown and Maloney, 2013).

Relatively high number of new generations of scab resistant cultivars are bred and proposed for the evaluation. Meanwhile, the older scab resistant cultivars are now in the production, though earlier releases such as Prima, Priscilla, Florina etc. are not well accepted because of poor fruit quality. Yet, Czech cultivar Topas is one of the most popular cultivars in organic orchards worldwide. It is extensively cultivated in the west and central Europe but was not tested at Nordic climate conditions. Judging on its ripening time in other countries where Topas is harvested after Golden Delicious, apparently it could be too late cultivar for Norway and not every year would reach optimal eating quality. Moderate temperatures during the relatively short growing season causing demanding cultivars not to reach fully developed fruit quality and is the main limiting factor for the introduction and successful growing of many new apple cultivars released in France, USA, New Zealand etc. Therefore cultivar testing should be performed continuously in order to select the best cultivars for the commercial growing and to keep Norwegian fruit growers competitive in the apple market.

Some multi-criteria analysis was suggested to evaluate the suitability of cultivation of novel apple cultivars before investing into new apple plantations (Rozman et al., 2015). However, the final decision what cultivar to plant depends on the apple producer, so cultivar evaluation trials performed at local growing conditions help growers to make their choices.

Two apple cultivar trials were planned and performed at NIBIO Ullensvang having the aims 1) to investigate scab resistance cultivars and advanced selections and select the most adapted for organic orchards, 2) to investigate recently bred premium cultivars and determine their suitability for the intensification of fruit production in Norway.

2 Materials and Methods

Apple cultivar trial 2011. *Investigation of Norwegian scab resistant cultivars and advanced selections*. Planting material of seven scab resistant cultivars and selections (Table 1) was grafted on M.9 rootstock and planted as one-year old whips in spring 2011. Planting distance was 3.5 x 0.9 m. Each cultivar was replicated ten times with one tree per plot.

Table 1. Apple cultivar trial 2011. Origin and parentage of scab resistant cultivars and advanced selections.

Cultivar	Country of origin	Parents
Blyberg	Norway	Chance seedling
Sonja (L II 5/13-08)	Norway	Ritt Bjerregaard x Isabel
L II 3/05-09	Norway	Ritt Bjerregaard x Isabel
Your Choice	Norway	Karen Schneider x BC 8C-27-96
L II 1/08-09	Norway	Ritt Bjerregaard x Isabel
L II 11/30-09	Norway	Aroma 'Fagravoll' x Isabel
Topas	Czech Republic	Rubin x Vanda

Apple cultivar trial 2008. *Investigation of premium apple cultivars*. Planting material of 13 cultivars and selections (Table 2) was grafted on M.9 rootstock and planted as one-year old whips in autumn 2008. Planting distance was 3.5 x 0.9 m. Each cultivar was replicated ten times with one tree per plot.

Table 2. Apple cultivar trial 2008. Origin and parentage.

Cultivar	Country of origin	Parents
NA 42 – 51	Norway, Graminor	Discovery x Julyred
MA982 06059	Norway, Graminor	Discovery x Astramel
Ritt Bjerregaard	Norway	Katinka x Ingelin
Dalili Embassy	France, Davodeau Ligonnière	Red sport of Delcorf
Aroma Fagravoll	Norway	Mutation of Aroma
Initial	France, INRA	Gala x Redfree
Gala Must	New Zealand	Mutation of Gala
Creston	Canada, Summerland	Golden Delicious X NJ 381049
Rubinstep (Pirouette®)	Czech Republic Holovousy	Clivia x Rubin
Lotos	Czech Republic	Otcovo x Jolana
Kanzi Nicoter	Belgium, Better3Fruits	Gala x Braeburn
Wellant	Netherlands	CPRO Selection x Elise
Greenstar	Belgium, Better3Fruits	Delbarestival x Granny Smith

Trees in both trials were trained as slender spindles. Pruning was performed in early spring at the dormant stage. In spring and summer, when necessary, trees were sprayed according to integrated pest management principals with labeled pesticides when local thresholds for pests and diseases were met. In general, tree health was good and insect pressure was low throughout the duration of the trials. Under-canopy management included grass in the inter-rows and clean-cultivated herbicide strips, 1-m wide in the intra-rows. The experimental site had a sandy loam soil with high organic matter (>4%) and with good fertility. Trees were irrigated by drip irrigation when water was deficient, based on evapotranspiration measurements. Trees received the same amounts of fertilizer, based on soil and leaf analysis.

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 $TCSA = \pi (d/2)^2$

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 TCSA in last year of experiment.

Average fruit weight (g) was calculated based on all fruits per every tree and total yield.

Fruit quality characteristics were determined on samples of 10 randomly collected fruits on four replications to be analysed on two different periods with a month between, totally 80 fruits per cultivar and year.

Fruit firmness (kg cm²) was measured by fruit texture digital measurer Durofel® 25 (Copa-Technology CTIFL, France) using standard probe 0,25 mm. 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.

Tendency of cultivars to biennial bearing habit was evaluated by alternate bearing index (ABI) according formula (Monselise and Goldschmidt, 1982):

$ABI = (year\ 1\ yield) - (year\ 2\ yield) / (year\ 1\ yield + year\ 2\ yield)$,
where ABI = 0 is no alternate bearing and ABI = 1.0 is complete alternate bearing.

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 phenological data is presented as an average of six years but yield and fruit quality parameters are presented as an average of the last four years when the apple trees entered full production phase.

3 Results and Discussions

Apple cultivar trial 2011. Investigation of Norwegian scab resistant cultivars and advanced selections.

Phenology. According to flowering time, all tested cultivars and advanced selections belong to early or medium flowering cultivar groups (Table 3). The earliest average dates of beginning and full flowering were recorded for Sonja, and the latest for L II 1/08-09. Full flowering dates differed between these two cultivars by 10 days. Flowering phenology was dependent on weather conditions. Differences between ‘early’ and ‘late’ years were from two weeks in the case of Topas up to 18 days in the case of L II 1/08-09. Long term evaluations of flowering phenology in Norway indicate that apple flowering becoming earlier due to a global warming (Rivero et al., 2017). Cultivars Blyberg and Topas distinguished significantly as the most abundant flowering, while L II 1/08-09 was rated the latest and significantly differed from all other cultivars in this group.

Table 3. Flowering phenology of tested cultivars, 2011 – 2017.

Cultivar	Average date of the beginning of flowering	Average date of full flowering	Average date of the end of flowering	Variation of full flowering date	Flowering abundance, (1-9)
Blyberg	16-May	20-May	29-May	10-26 May	7.2 a
Sonja (L II 5/13-08)	14-May	18-May	27-May	9-26 May	6.2 abc
L II 3/05-09	17-May	21-May	29-May	13-28 May	5.1 c
Your Choice	20-May	23-May	01-Jun	15-30 May	5.7 bc
L II 1/08-09	23-May	28-May	05-Jun	19 May–06 Jun	2.2 d
L II 11/30-09	20-May	23-May	01-Jun	15-30 May	5.0 c
Topas	17-May	21-May	29-May	13-27 May	6.9 ab

According to fruit ripening and harvest time cultivars belong to four groups: early cultivars – Blyberg, medium cultivars – Sonja, L II 3/05-09, Your Choice and L II 1/08-09, late cultivars – L II 11/30-09 and very late cultivars – Topas (Table 4). As well as flowering time fruit harvest dates depended on weather conditions in each particular growing season and these differences were even more pronounced. Variation of harvest date of different cultivars was from 18 days (Blyberg) until one month or even 40 days (Topas). Harvest time later than mid-October is already risky under Norwegian conditions, and Topas felt in this late harvest window even 5 out of 6 seasons.

Table 4. Fruit harvest dates of tested cultivars at full bearing stage, 2014-2017

Cultivar	Average harvest date	Variation of harvest date	Difference in days between earliest and latest harvest dates
Blyberg	20-Aug c	11 – 29 Aug	18
Sonja (L II 5/13-08)	12-Sep b	27 Aug – 21 Sep	25
L II 3/05-09	12-Sep b	27 Aug – 26 Sep	30
Your Choice	15-Sep b	27 Aug – 01 Oct	35
L II 1/08-09	20-Sep b	06 Sep– 09 Oct	34
L II 11/30-09	28-Sep ab	15 Sep – 09 Oct	24
Topas	12-Oct a	23 Sep – 02 Nov	40

Yield and tree productivity. The first fruits were harvested in the second year of planting, only L II 1/08-09 did not yield until the 4th year in the orchard and stayed significantly behind all other cultivars during all years of investigations (Fig.1). Most of cultivars increased the annual yield until the 7th leaf (Fig.2), therefore their alternate bearing index (ABI) was very low (Table 5). Some tendencies of biennial bearing were noticed only for Your Choice and L II 3/05-09.

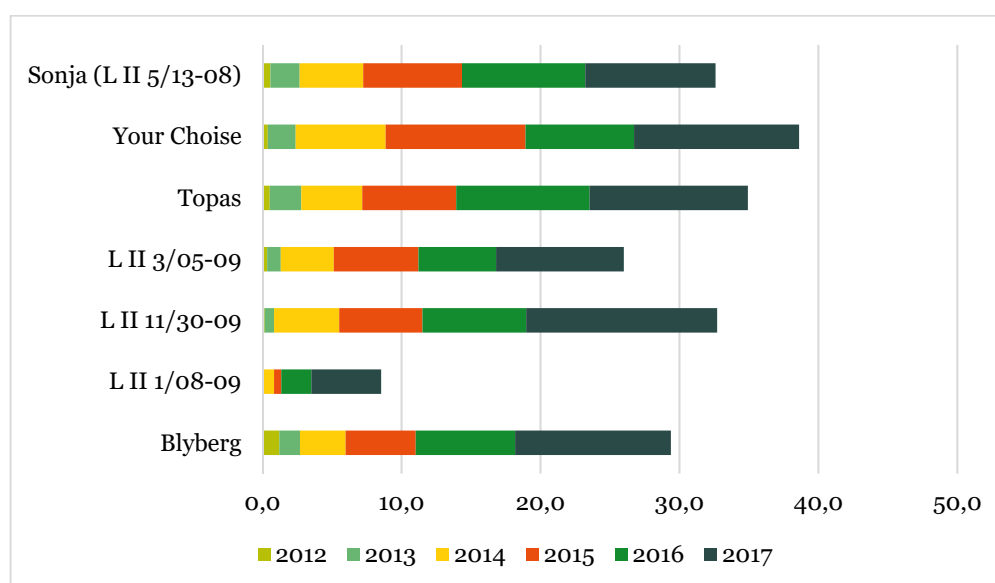


Fig. 1. Annual yield of tested cultivars during the trial period, 2012-2017, kg/tree.

Your Choice gave significantly highest cumulative yield and only cumulative yield of Topas did not differ from it (Table 5). The second group of high yielding cultivars were Sonja and L II 11/30-09. The selection L II 1/08-09 gave significantly the lowest cumulative yield which was up to 4-5 times lower than other cultivars.

The most vigorous cultivars were Your Choice and L II 11/30-09. Their tree trunk cross sectional area (TCSA) was almost double as TCSA of Sonja and Topas that exhibit significantly the lowest tree vigour.

Table 5. Tree growth, yield, productivity and annual bearing index (ABI) of tested cultivars, 2012-2017.

Cultivar	TCSA, cm ² 2017	Cumulative yield, kg tree	Cumulative productivity, kg/cm ² TCSA	ABI
Blyberg	16.2 cde	29.13 cd	1.86 bc	0.00 a
Sonja (L II 5/13-08)	12.4 e	32.66 bc	2.65 a	0.02 a
L II 3/05-09	16.5 cd	25.08 d	1.58 c	0.28 b
L II 1/08-09	18.1 bc	8.54 e	0.45 d	0.15 ab
Your Choice	20.9 ab	38.76 a	2.17 b	0.21 b
L II 11/30-09	22.1 a	32.75 bc	1.50 c	0.13 ab
Topas	14.2 de	34.94 ab	2.52 a	0.00 a

By combining yield and tree vegetative growth parameters, it is possible to judge how effective are cultivars directing assimilates to fruit set and fruit growth instead of increasing wood mass. According cumulative productivity all cultivars fall into distinctive groups. Sonja and Topas were the most productive, followed by Your Choice. Blyberg did not differed significantly from the latter cultivar, but at the same time did not differ from less productive cultivars in the third group - L II 11/30-09 and L II 3/05-09. L II 1/08-09 gave the lowest yield of the tested cultivars and advanced selections.

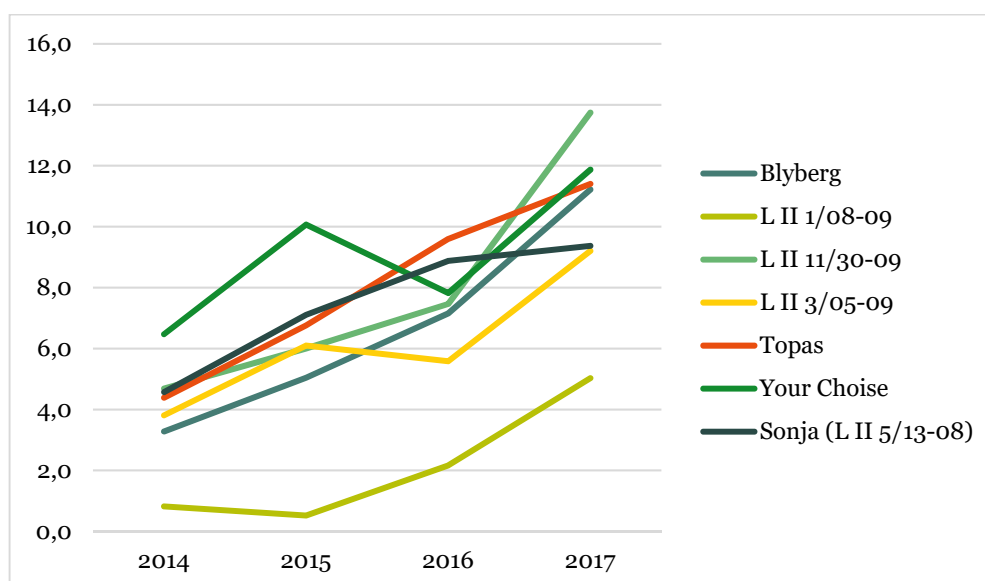


Fig. 2. Cropping pattern of tested cultivars during the full bearing stage, kg/tree.

Fruit quality. During fruit sensory analysis L II 11/30-09 and Blyberg apples received the highest taste score. Sonja and Your Choice got lower evaluation, but not significantly. L II 3/05-09 fruits were least tasty and got very low scores. Not sufficient fruit taste of Topas in most of years proved again that this cultivar is risky to grow at the short Norwegian vegetation period.

Average fruit weight of the tested cultivars differed, but significant differences were found only between L II 11/30-09 with the largest fruits and Topas and L II 3/05-09 as the smallest ones (Table 6). Lower average fruit weight of Topas comparing to other widely grown cultivars is reported from Czech trials too (Paprstein and Sedlak, 2019). All cultivars had a very high share of fruits that meet requirements for the Class 1 and there were no significant differences between them. Average fruit

weight directly correlated with the crop loads. During the last four years of the experiment when the trees were given considerable yields, the average fruit number per tree of all cultivars increased from 14 up to 68, and at the same time the average fruit weight of all cultivars decreased from 228 to 131 g. During this period variation of the average fruit weights of individual cultivars was around or more than 100 g for Sonja, Your Choice, and L II 11/30-09 (Fig. 3). All these cultivars had the largest fruits. Less variation (but still 69-82 g) of average fruit weight between years was recorded for L II 3/05-09, L II 1/08-09 and Topas.

Table 6. Average fruit weight, grading and taste evaluation of tested cultivars, average 2014-2017.

Cultivar	Average fruit weight, g	Class 1 fruits, %	Taste
Blyberg	159 ab	93.9	7.3 a
Sonja (L II 5/13-08)	178 ab	98.8	6.5 abc
L II 3/05-09	145 b	97.7	4.7 d
L II 1/08-09	167 ab	98.7	5.0 cd
Your Choice	180 ab	98.0	6.6 abc
L II 11/30-09	206 a	99.6	7.4 a
Topas	150 b	98.0	5.3 cd

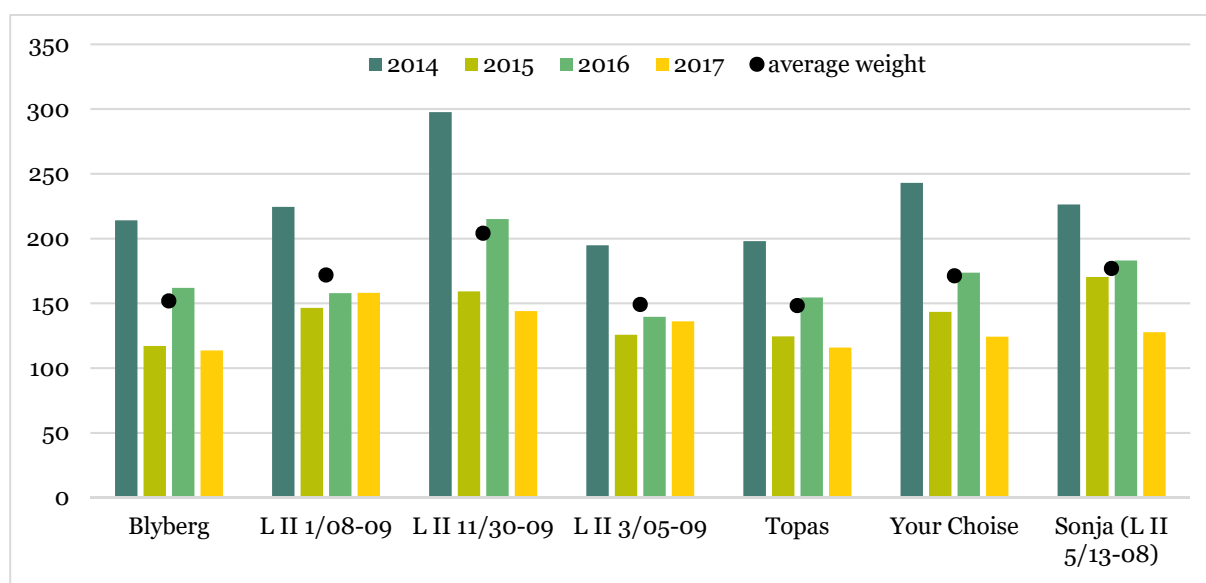


Fig.3. Variation of fruit weights during 2014-2017, g.

The highest yield of all cultivars was harvested in the last year of the experiment (Table 7). Excluding low yielding selection L II 1/08-09, the highest fruit weight (144 g) was recorded for L II 11/30-09, which gave the highest yield as well. Blyberg and Topas had the smallest fruits. It clearly demonstrated that yield of most tested cultivars could be around 30 t/ha or more than 40 t/ha can be harvested from Your Choice and L II 11/30-09.

Table 7. Apple yield and average fruit weight in 2017.

Cultivar	Yield 2017, kg tree	Yield 2017, t ha	Average fruit weight 2017, g
Blyberg	11.2 ab	35.6	114
Sonja (L II 5/13-08)	9.4 b	29.7	128
L II 3/05-09	9.2 b	29.2	136
L II 1/08-09	5.0 c	16.0	158
Your Choice	11.9 ab	37.7	124
L II 11/30-09	13.7 a	43.6	144
Topas	11.4 ab	29.7	116

Two latest in ripening time cultivars, Topas and L II 11/30-09, had the firmest fruits at harvest (Table 8). Only Sonja has comparable fruit firmness. All these cultivars had the lowest decrease (approx. 20%) of fruit firmness during the storage, when L II 3/05-09, L II 1/08-09 and Your Choice lost their firmness around 30 and more percent. Such differences in fruit firmness between early and late ripening cultivars have been noticed in other cultivar evaluation trials as well (Tahir et al., 2015).

Table 8. Fruit firmness at harvest and after the storage, kg cm²

Cultivar	Fruit firmness at harvest	Fruit firmness after 1-month storage	Softening rate, %
Blyberg	7.1 c	-	-
Sonja (L II 5/13-08)	8.0 abc	5.3 c	21
L II 3/05-09	6.6 c	4.8 c	27
L II 1/08-09	7.7 bc	6.1 bc	34
Your Choice	7.3 c	5.0 c	33
L II 11/30-09	9.1 ab	7.3 ab	20
Topas	9.3 a	7.6 a	19

The highest soluble solid contents (SSC) at harvest time was found in L II 1/08-09 fruits and only fruits of L II 11/30-09 and Topas did not differ significantly (Table 9). Significantly lowest SSC was detected in fruits of Blyberg, Sonja and L II 3/05-09. After one month of storage the same tendencies were established. . Topas at harvest and L II 11/30-09 with Topas after one month of storage had significantly higher fruit acidity than all other cultivars. High acidity of Topas apples is recorded in numerous trials. Between other cultivars there were some significant differences at harvest time when fruits of L II 3/05-09 and L II 1/08-09 had the lowest acid content, but there were no differences after one month of storage.

Table 9. Fruit biochemical content, %. Average 2014 – 2017.

Cultivar	SSC at harvest	SSC after 1-month storage	Acidity at harvest,	Acidity after 1-month storage	SSC/TA at harvest	SSC/TA after 1-month storage
Blyberg	10.7 c	-	0.82 b	-	15.3 bc	-
Sonja (L II 5/13-08)	11.1 c	11.5 c	0.58 cd	0.48 b	19.4 b	25.3 a
L II 3/05-09	11.2 c	11.5 c	0.46 d	0.55 b	25.9 a	23.0 ab
L II 1/08-09	12.7 a	12.2 ab	0.47 d	0.45 b	27.0 a	27.2 a
Your Choice	11.6 bc	11.8 bc	0.73 bc	0.59 b	16.0 bc	20.9 abc
L II 11/30-09	12.1 ab	12.4 a	0.83 b	0.84 a	14.3 c	14.9 bc
Topas	12.1 ab	12.0 abc	1.03 a	0.88 a	11.8 c	13.8 c

Despite high SSC in fruits of Topas and L II 11/30-09, high acidity level at the same time determined significantly the lowest ratio of soluble solid content and acidity. The fruit flavour of these cultivars had prevailing acid character.

Significantly the highest ratio of SSC and acidity was found in L II 3/05-09 and L II 1/08-09 fruits at harvest time. The fruit flavour of these cultivars had prevailing sweet character. After the storage this parameter did not differ significantly from Sonja and Your Choice fruits.

Cultivar descriptions.

BLYBERG

Parents	Chance seedling
Flowering	Abundant, mid-season bloom.
Ripening time	Early. Between Vista Bella and Discovery
Precocity	Comes steadily into production.
Yield	Moderate in the young orchard and high (up to 35 t/ha) in the productive orchard. No biennial bearing observed. Two picks recommended.
Storage	Max 3-4 weeks

Fruit

Round -oblong shape with almost no cover colour. Thick stem and shallow calyx. Large fruit size for early season cultivars. Average fruit weight 159 g, when high yield - 114 g. A mild, creamy like, aromatic and good taste. Lack of taste if harvested too early. Medium fruit firmness and acidity, low soluble solid content.

Drawbacks Fruits can get bruising, susceptible to bitter pit, easy drops, lack of taste if harvested too early

Tree growth Moderate

Disease resistance Tolerant to scab.

Conclusion Blyberg can be recommended for a small-scale production for road sale and amateurs gardens.



L II 3/05-09

Parents	Ritt Bjerregaard x Isabel
Flowering	Low, mid-season bloom.
Ripening time	Medium. 5-7 days before Summered.
Precocity	Comes steadily into production.
Yield	Low in the young orchard and moderate (up to 29 t/ha) in the productive orchard. Biennial bearing. Two picks recommended.
Storage	Till November. Grainy fruit flesh structure after mid of November.
Fruit	Cylinder-oblong, furrowed fruits with lined edges around. Dark red blush on 50 - 60 % of the fruit surface. A relative deep calyx. Large fruit size. Average fruit weight 145 g, when high yield - 136 g. Lack of taste. Low fruit firmness, soluble solid content and acidity.
Drawbacks	Easy drops, lack of juiciness and crunchiness. Thick, tough skin.
Tree growth	Moderate. Spreading canopy.
Disease resistance	Scab resistant.

Conclusion L II 3/05-09 has no commercial value under the growing conditions tested due to low fruit quality.



Sonja (L II 5/13-08)

Parents	Ritt Bjerregaard x Isabel
Flowering	Abundant, early-season bloom.
Ripening time	Medium. 5-7 days before Summered.
Precocity	Comes fast into production.
Yield	High. Annual bearing.
Storage	Till mid of November

Fruit

Round-conic with lined edges around the calyx. A deep calyx. Dark blue-red blush on 60 % of the fruit surface.

Very large fruit size. Average fruit weight 178 g, when high yield - 128 g.

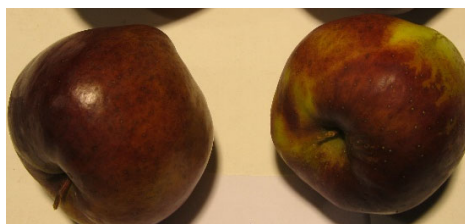
The taste is good, mild and cream like. High fruit firmness, low soluble solid content and acidity.

Drawbacks Fruits get russetting in some years.

Tree growth Low.

Disease resistance Scab resistant.

Conclusion Despite of high yield and good taste of fruits Sonja has no commercial value under the growing conditions tested due to not attractive surface colour and uneven fruit shape.



Not attractive appearance of Sonja fruits at artificial light.

L II 11/30-09

Parents	Aroma 'Fagravoll' x Isabel
Flowering	Moderate, mid-season bloom.
Ripening time	Late. 2 days before Aroma.
Precocity	Comes steadily into production.
Yield	High. Annual bearing.
Storage	Until December. Shelf life 8 days.

Fruit

Flattened round fruits with nice red blush on 30 % of the fruit surface and smooth skin. Appearance like Aroma.

Very large fruit size. Average fruit weight 206 g, when high yield - 144 g.

The taste is very good, fresh and cream like. High fruit firmness and soluble solid content and medium acidity. Juicy, a bit aromatic flesh.

Drawbacks Aroma cultivar like fruits, but cannot compete in storability

Tree growth Very vigorous. Spreading canopy.

Disease resistance Scab resistant.

Conclusion Despite of high yield and very good fruit quality parameters L II 11/30-09 has very similar appearance as Aroma fruits and the same harvest window, but shorter storage. Therefore it cannot replace the standard cultivar Aroma.



Your Choice

Parents	Karen Schneider x BC 8C-27-96
Flowering	Moderate, late-season bloom.
Ripening time	Medium. 2 days before Summered.
Precocity	Comes fast into production.
Yield	Very high. Biennial bearing. Multiple picks recommended
Storage	Till the November

Fruit

Flattened round fruits with nice red blush and smooth skin. Medium deep calyx cavity and medium to short stem in a medium deep stem cavity.

Large fruit size. Average fruit weight 180 g, when high yield it drops down to 124 g.

The taste is good. Less fruit firmness, medium soluble solid content and acidity.

Drawbacks Weak bruising, short storage

Tree growth Vigorous. Upright growth.

Disease resistance Tolerant to scab.

Conclusion Your Choice gives nice, good tasting apples for autumn consumption. The limited, ecological production and distribution is done within the authority of Choice Hotels, which is the owner of this cultivar. Your Choice is therefore not available for growers without a production contract with Choice Hotels.



Topas

Parents	Rubin x Vanda
Flowering	Abundant, mid-season bloom.
Ripening time	Very late. 10-12 days after Aroma.
Precocity	Comes fast into production.
Yield	Very high. Annual bearing.
Storage	Develop greasy surface by the end of November, storable till mid-January when fruits develop distinct aromatic taste.

Fruit

Round mottled coloured fruits.

Medium fruit size. Average fruit weight 150 g, when high yield drops down sharply to 116 g.

Lack of taste. Very firm fruits and very high acidity.

The other test years the fruit did not reach acceptable fruit quality due to very high acid content and lack of taste. Fruit size are too small when trees bear full yield.

Drawbacks Varying fruit quality from one year to another.

Tree growth Moderate. Upright growth.

Disease resistance Scab resistant. Very susceptible to mildew.

Conclusion Topas has no commercial value under the growing conditions tested due to too late ripening.



L II 1/08-09

Parents	Ritt Bjerregaard x Isabel
Flowering	Very low, late-season bloom.
Ripening time	Medium. 3 days after Summered.
Precocity	Comes very slowly into production.
Yield	Very low.
Storage	Until mid-November

Fruit

Flattened, furrowed fruits with distinct lined edges around deep calyx. Red - blue blush and highly visible red coloured lenticels.

Large fruit size. Average fruit weight 167 g.

Moderate taste. High soluble solid content and low acidity.

Drawbacks Not nice fruit appearance and very low productivity

Tree growth Extremely vigorous. Upright canopy.

Disease Scab resistant.

resistance

Conclusion L II 1/08-09 has no commercial value under the growing conditions tested due to very low yields and insufficient fruit quality.

Apple cultivar trial 2008.

Phenology. According to flowering time, tested cultivars belong to early or medium flowering cultivar groups (Table 10). The earliest average dates of beginning and full flowering were recorded for NA 42 – 51 and Dalili Embassy, and the latest for Gala Must. Full flowering dates differed between these cultivars by 7-8 days. Flowering phenology was dependent on weather conditions in particular season. Latest flowering was recorded in 2013, when all cultivars reached full bloom stage only in the first decade of June. Difference with earliest flowering dates was up three weeks, and all tested cultivars had the same tendencies. Rubinstep and Aroma (standard) were included in previous cultivar trial performed in 2002-2009 (Kvamm-Lichtenfeld et al., 2012). Despite of climate warming, average full flowering dates of Rubinstep and Aroma in this trial were 3 days later than in previous one. It contradicts to overall tendency and it could be a source for further discussions of the stability of climate change. Previously, the effects of air temperature during the winter and spring months on cherry flowering phenology were evaluated for two 5-year periods 1996-2000 and 2003-2007 (Meland et al., 2017). Increased temperatures in May resulted in significantly earlier flower development in the later period of observations.

Apple trees of selection NA 42 – 51 had the most abundant flowering. The least flowering was recorded for another selection MA982 06059. Flowering abundance of the rest of cultivars felt in between them.

Table 10. Flowering phenology of tested cultivars, 2011-2016

Cultivar	Average date of the beginning of flowering	Average date of full flowering	Average date of the end of flowering	Variation of full flowering date	Flowering abundance, 1-9 point
NA 42 – 51	17-May	20-May	29-May	10-May - 01-Jun	7.7 a
MA982 06059	17-May	21-May	29-May	08-May - 02-Jun	4.7 e
Ritt Bjerregaard	18-May	22-May	31-May	13-May - 02-Jun	6.6 abc
Dalili Embassy	17-May	20-May	28-May	12-May - 04-Jun	5.2 cde
Aroma Fagravoll	22-May	26-May	03-Jun	15-May - 05-Jun	5.0 de
Gala Must	25-May	28-May	06-Jun	20-May - 08-Jun	6.9 ab
Initial	23-May	27-May	04-Jun	18-May - 06-Jun	5.8 bcde
Creston	19-May	22-May	31-May	12-May - 01-Jun	5.9 bcde
Rubinstep (Pirouette®)	18-May	22-May	31-May	12-May - 02-Jun	6.6 abc
Lotos	18-May	22-May	30-May	13-May - 02-Jun	6.2 bcd
Kanzi Nicoter	17-May	21-May	29-May	11-May - 01-Jun	6.7 abc
Wellant	22-May	26-May	03-Jun	16-May - 06-Jun	6.3 abcd
Greenstar	22-May	26-May	03-Jun	16-May - 05-Jun	5.4 cde

According to fruit ripening and harvest time cultivars belong to four groups: early cultivar – NA 42 – 51, medium cultivars – MA982 06059, Ritt Bjerregaard, and Dalili Embassy, late cultivars – Aroma Fagravoll, Gala Must, Initial, Creston, Rubinstep, Lotos and Kanzi and very late cultivars – Wellant and Greenstar (Table 11). Comparing data with the cultivar trial performed in 2002-2009 (Kvamm-Lichtenfeld et al., 2012), average harvest dates of Rubinstep and Aroma were delayed by 3 – 4 days approximately the same as date of full flowering.

Depending of the vegetation conditions during the particular growing season, variation of harvest dates of different cultivars was from 3 weeks (NA 42 – 51, MA982 06059) till 39 days (Gala Must) or even 43 days (Creston). Due to such year effect on fruit ripening time, even 4-5 seasons out of 6 were too late for the cultivars Lotos, Wellant and Greenstar. Even considering climate warming, these three cultivars are not yet suitable to grow in Norway. During three seasons, fruits of Gala Must, Kanzi and Creston were harvested later than 10th of October, while Aroma Fagravoll and Rubinstep had 1 and 2 late harvests respectively. Gala Must, Kanzi and Creston should be considered as the latest possible cultivars at the Norwegian climate conditions.

Table 11. Fruit harvest dates of tested cultivars, 2012-2016

Cultivar	Average harvest date	Variation of harvest date	Difference in days between earliest and latest harvest dates	Number of too late seasons out of 6 (harvest > 10-Oct)
NA 42 – 51	20-Aug a	07 – 30 Aug	23	0
MA982 06059	08-Sep b	27-Aug – 17-Sep	21	0
Ritt Bjerregaard	10-Sep b	27- Aug – 23-Sep	27	0
Dalili Embassy	16-Sep b	30-Aug – 01-Oct	33	0
Aroma Fagravoll	01-Oct c	12-Sep – 15-Oct	34	1
Gala Must	03-Oct cd	11-Sep – 19-Oct	39	3
Initial	04-Oct cde	18-Sep – 19-Oct	32	2
Creston	07-Oct cde	11-Sep – 23-Oct	43	3
Rubinstep (Pirouette®)	07-Oct cde	16-Sep – 17-Oct	32	2
Lotos	07-Oct cde	22 Sep – 17-Oct	28	4
Kanzi Nicoter	10-Oct cde	24-Sep – 19-Oct	26	3
Wellant	17-Oct de	26-Sep – 23-Oct	28	4
Greenstar	18-Oct e	25-Sep – 24-Oct	30	5

Yield and tree productivity.

Lotos, Kanzi and Gala Must were the most precocious cultivars and started to yield in 2010 (Fig.4). Surely, the first yields were low and did not reach 1 kg/tree, but other cultivars delayed their harvest by one year, and MA982 06059 and Initial started to yield only 2012. Most of cultivars were increasing yield until the fifth year in the orchard. However, after abundant harvest in 2015 all tested cultivars switched to alternate bearing mode, except MA982 06059 that moderately cropped every year (Fig.5). Wellant started to alternate already after the third and Initial after the first harvest. During the trial period, the highest significant alternate bearing index (ABI) was recorded for cultivars Initial, Dalili Embassy and Aroma Fagravoll (Table 12). High ABI was also recorded for cultivars Creston, Rubinstep and Greenstar. Other tested cultivars were less prone to biennial bearing and did not differ significantly between each other. The only not alternating cultivar was MA982 06059 but the yield was the lowest.

The most abundant yield was harvested from Lotos trees (Table 12). Creston, Rubinstep, Kanzi and Greenstar gave significantly lower cumulative yield comparing to Lotos, but significantly higher than all other cultivars. Dalili Embassy gave the lowest yield in the tested group of cultivars.

Two cultivars Rubinstep and NA 42 – 51 were the most vigorous. More than two times smaller tree trunk cross sectional area (TCSA) was recorded for Aroma Fagravoll, Dalili Embassy and Greenstar. It

is interesting that in previous trial Rubinstep and standard Aroma had the same tree vigour (Kvamm-Lichtenfeld et al., 2012). All other tested cultivars fell between these two groups and exhibited moderate tree vigour.

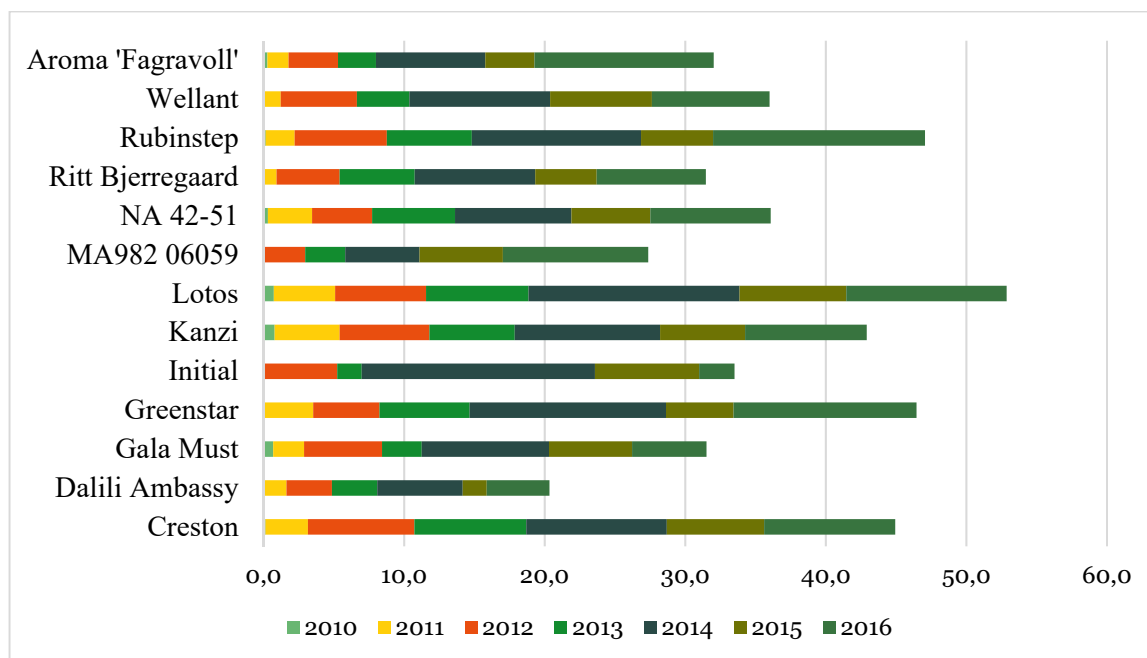


Fig. 4. Annual yield of tested cultivars during the trial period, 2010-2016, kg/tree.

Table 12. Tree growth, yield, productivity and annual bearing index (ABI) of tested cultivars, 2012-2017.

Cultivar	TCSA, cm ²	Cumulative yield, kg tree	Cumulative productivity, kg/cm ² TCSA	ABI
NA 42 – 51	20.3 a	36.1 c	1.78 f	0.15 e
MA982 06059	14.1 bcd	27.4 d	1.94 ef	0.02 f
Ritt Bjerregaard	16.9 b	32.7 cd	1.94 ef	0.20 de
Dalili Embassy	10.4 e	20.5 e	1.97 ef	0.49 a
Aroma Fagravoll	9.9 e	32.0 cd	3.98 ab	0.44 ab
Gala Must	12.7 cde	31.5 cd	2.47 de	0.27 cd
Initial	15.8 bc	33.8 c	2.14 def	0.57 a
Creston	13.8 bcde	44.0 b	3.19 bc	0.36 bc
Rubinstep (Pirouette®)	21.3 a	47.1 b	2.21 def	0.36 bc
Lotos	14.1 bcd	56.1 a	3.53 b	0.19 de
Kanzi Nicoter	12.1 de	42.9 b	3.25 bc	0.27 cd
Wellant	13.4 cde	36.2 c	2.71 cd	0.20 de
Greenstar	10.2 e	46.5 b	4.54 a	0.31 bcd

Greenstar was the most productive cultivar. Only cumulative productivity of Aroma Fagravoll did not differ significantly (Table 12). Cumulative productivity of Kanzi, Lotos and Creston was comparable to Aroma Fagravoll. Selections NA 42 – 51 and MA982 06059, cultivars Ritt Bjerregaard and Dalili Embassy were the least productive among the tested group.

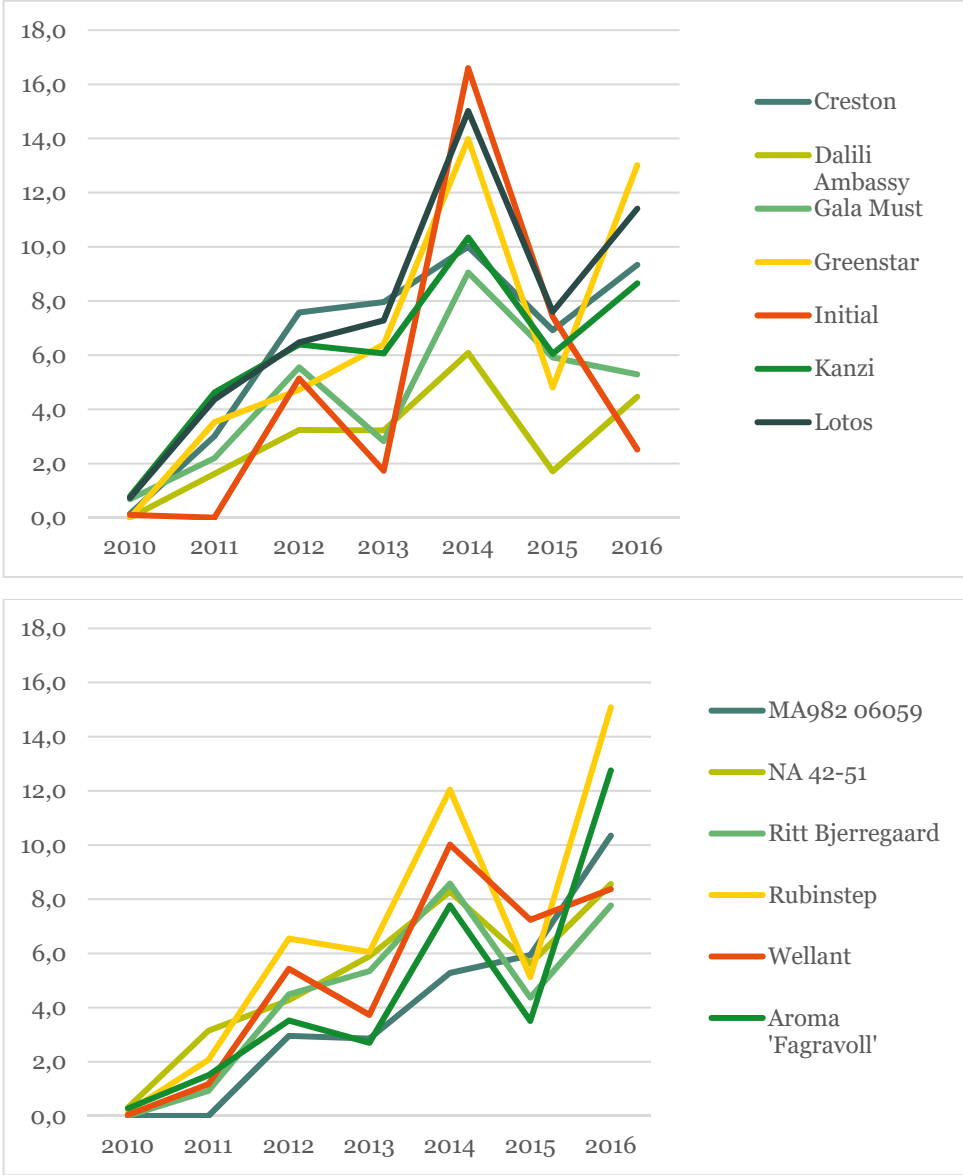


Fig. 5. Cropping tendencies of tested cultivars during the full bearing stage, kg/tree.

Fruit quality. The selection MA982 06059 had significantly the largest fruits and the average weight during 4 harvest reached 226 g (Table 13). Only two other cultivars, Aroma Fagravoll and Initial, had comparable fruit sizes. Though fruit weight of Sselection MA982 06059 was determined mainly by the 2013 season when their reached around 300 g, but the tendency of bigger fruits remained in 2015 and 2016 too (Fig.6). It could be correlated with moderate crops of this selection. Ritt Bjerregaard and Gala had the smallest fruits. However, there were no significant differences comparing their average fruit weight with NA 42 – 51, Dalili Embassy and Rubinstep. Smaller weight of Gala fruits is reported from other countries too (Paprstein and Sedlak, 2019).

Table 13. Average fruit weight, grading and taste evaluation of tested cultivars, average 2013-2016.

Cultivar	Average fruit weight, g	Class 1 fruits, %	Taste
NA 42 – 51	123 fg	95	5.8 abc
MA982 06059	226 a	99	6.5 ab
Ritt Bjerregaard	114 g	94	3.0 c
Dalili Embassy	139 efg	96	4.5 bc
Aroma Fagravoll	196 abc	99	7.5 a
Gala Must	113 g	74	4.6 bc
Initial	200 ab	100	5 abc
Creston	166 cde	94	6.4 ab
Rubinstep (Pirouette®)	137 efg	96	7.3 a
Lotos	149 def	99	6.0 ab
Kanzi Nicoter	149 def	91	5.4 abc
Wellant	161 de	95	6.9 ab
Greenstar	175 bcd	99	5.3 abc

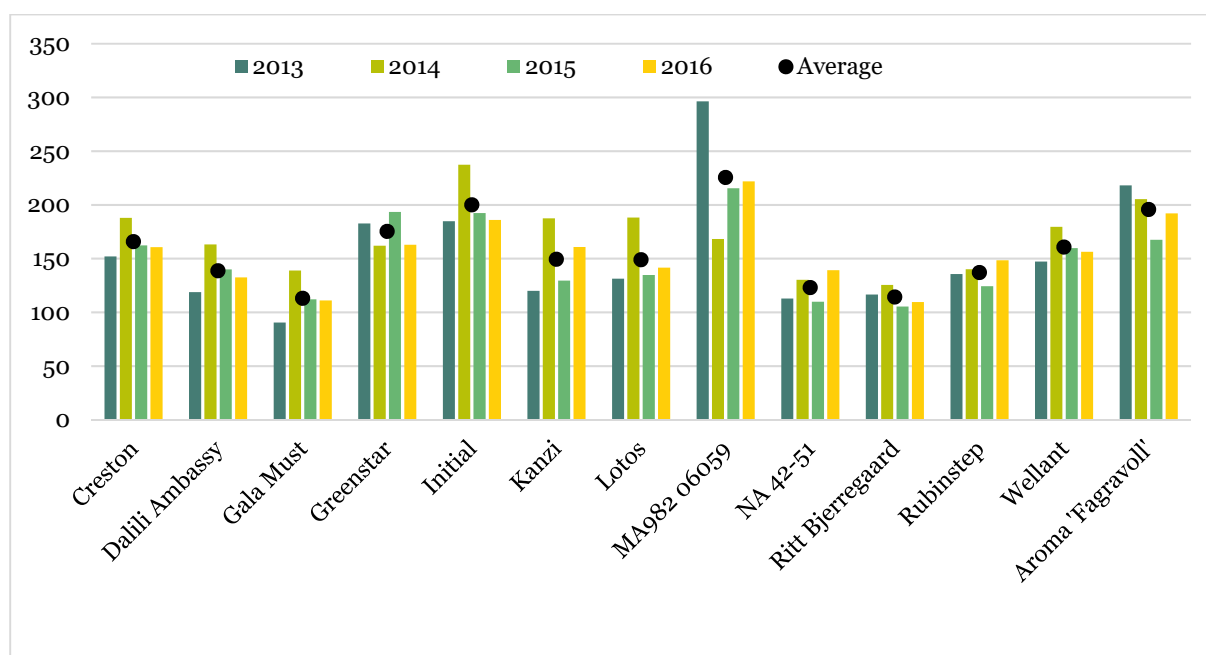


Fig. 6. Variation of fruit weights of different cultivars during 2013-2016 and average fruit weight, g.

Greenstar, Kanzi Nicoter, Rubinstep and Initial had the firmest fruits at harvest (Table 14). Aroma Fagravoll and Dalili Embassy fruit firmness was significantly lower. Four latest in ripening time cultivars Greenstar, Kanzi Nicoter, Wellant and Lotos had the lowest decrease (approx. 4-10%) of fruit firmness during the storage when the rest of cultivars lost their firmness around 20 and more percent.

Table 14. Fruit firmness at harvest and after 1- month storage, kg cm²

Cultivar	Fruit firmness at harvest	Fruit firmness after 1-month storage	Softening rate, %
NA 42 – 51	8.1 def	-	-
MA982 06059	7.3 efg	6.4 de	13
Ritt Bjerregaard	6.8 fg	5.0 e	26
Dalili Embassy	6.2 g	5.0 e	20
Aroma Fagravoll	6.3 g	5.1 e	18
Gala Must	9.5 bcd	7.5 cd	22
Initial	10 abc	7.8 bcd	22
Creston	8.8 cde	6.9 cd	21
Rubinstep (Pirouette®)	10.5 ab	8.4 bc	20
Lotos	8.6 cde	7.7 bcd	10
Kanzi Nicoter	10 abc	9.4 ab	6
Wellant	8.5 de	8.2 bc	4
Greenstar	11.3 a	10.8 a	4

All tested cultivars did not distinguish by high soluble solid content and only some significant differences were found between them. SSC content in Wellant fruits was the highest at harvest and after the storage (Table 15).

Combination of low content of SSC and high acidity of Aroma, Kanzi and Lotos fruits led to the significantly the lowest SSC/TA ratio. The fruit flavour of these cultivars had prevailing acid character. Low SSC/TA ratio in Aroma fruits were reported in Denmark (Vega et al., 2014) or described as medium sweet and medium sour in Finland (Seppä et al., 2016).

Combination of low content of SSC and significantly the lowest acidity of Ritt Bjerregaard and Gala Must fruits led to the significantly the highest SSC/TA ratio both at harvest and after the storage. The fruit flavour of both cultivars had prevailing sweet character. It is interesting that the taste of both cultivars got the lowest scores (Table 13). This phenomenon that in Northern Europe, sourness is usually better accepted than elsewhere was reported by Bonany et al. (2013).

Table 15. Fruit biochemical content, %, average 2013 – 2016.

Cultivar	SSC at harvest	SSC after 1-month storage	Acidy at harvest,	Acidy after 1-month storage	SSC/TA at harvest	SSC/TA after 1-month storage
NA 42 – 51	11.6 b	-	0.57 cd	-	20.3 cd	-
MA982 06059	12.4 ab	12.5 ab	0.72 ab	0.66 abc	17.1 def	18.8 bcd
Ritt Bjerregaard	11.4 b	11.7 b	0.42 e	0.45 d	27.8 a	26.6 a
Dalili Embassy	12.2 ab	12.0 b	0.80 a	0.64 abc	15.3 ef	18.8 cd
Aroma Fagravoll	11.7 b	12.0 b	0.78 a	0.72 a	15.3 f	16.8 d
Gala Must	11.9 b	12.3 ab	0.48 de	0.45 d	24.8 ab	27.6 a
Initial	12.3 ab	13.0 ab	0.65 bc	0.59 bc	19.3 cde	22.5 b
Creston	12.2 ab	12.2 ab	0.65 bc	0.54 cd	18.1 cdef	22.7 b
Rubinstep (Pirouette®)	12.3 ab	13.0 ab	0.70 ab	0.60 bc	17.3 cdef	21.8 bc
Lotos	11.8 b	12.4 ab	0.78 a	0.69 ab	14.7 f	17.8 d
Kanzi Nicoter	11.2 b	12.0 b	0.79 a	0.69 ab	14.0 f	17.4 d
Wellant	13.6 a	13.5 a	0.64 bc	0.65 abc	21.4 bc	20.1 bcd
Greenstar	12.2 ab	12.4 ab	0.62 bc	0.61 bc	19.9 cd	20.3 bcd

Cultivar descriptions.

NA 42 – 51

Parents	Discovery x Julyred
Flowering	Abundant, mid-season bloom.
Ripening time	Early. Between Vista Bella and Discovery.
Precocity	Comes fast into production.
Yield	Moderate. Low biennial bearing habit observed. Multiple picks recommended. Low cumulative productivity.
Storage	Short. 2 – 3 weeks.
Fruit	<p>Conic-ovoid fruits with shallow calyx and stem cavity with short stem. Red colour covers the fruit, but the fruit gains the colour just before it reaches ripen stage. Medium fruit size. Average fruit weight 123 g. The taste is medium to good depending on year conditions. High fruit firmness, medium soluble solid content and low acidity.</p>
Drawbacks	Abundant fruit drop. Fast fruit flesh browning.
Tree growth	Very vigorous.
Disease resistance	Tolerant to scab and mildew.

Conclusion NA 42-51 has no commercial value under the growing conditions tested due to varying fruit quality and abundant fruit drop.



MA982 06059

Parents	Discovery x Astramel
Flowering	Low, mid-season bloom.
Ripening time	Medium. 1 - 2 days before Discovery.
Precocity	Comes slow into production.
Yield	Low. Annual bearing. Low cumulative productivity.
Storage	Till mid of October. Early fruit shrivelling.

Fruit

Round-flattened fruits with shallow calyx cavity and stem cavity with a short stem. Light red blush on 50 % of the fruit surface.

Very large fruit size. Average fruit weight 226 g.

The taste is very good, mild with good sugar/acid balance. Medium fruit firmness, high soluble solid content and acidity.

Drawbacks Easy fruit drop. Sensitive to russetting. Cracking in the stem cavity and rotting. Thin skin easy bruises. Very susceptible to bitter pit.

Tree growth Moderate after coming in the production.

Disease resistance Scab and mildew resistant. Moderate sensitivity to tree canker.

Conclusion	Despite of nice appearance and good taste of fruits the selection MA982 06059 has no commercial value under the growing conditions tested due to low yield and productivity, susceptibility to bitter pit, bruising, russetting and cracking, and easy fruit drop.
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Ritt Bjerregaard

Parents	Katinka x Ingelin
Flowering	Abundant, mid-season bloom.
Ripening time	Medium. The same as Discovery.
Precocity	Comes slow into production.
Yield	Medium. Low biennial bearing habit observed. Low cumulative productivity.
Storage	Till mid of October

Fruit

Round-flattened, lined around calyx cavity. A deep stem cavity with medium long stem. Dark red blush on 50 % of the fruit surface.

Small fruits. Average fruit weight 114 g.

The taste is insufficient. Medium fruit firmness, low soluble solid content and acidity.

Drawbacks Easy fruit drop. Cracking in the stem cavity. Thin skin easy bruises. Susceptible to bitter pit.

Tree growth Medium. Slender, somewhat upright growth habit.

Disease resistance Scab resistant. Sensitive to tree canker.

Conclusion **Ritt Bjerregaard** has no commercial value under the growing conditions tested due to little attractive appearance, low fruit quality and weak taste, susceptibility to bitter pit, bruising, cracking, and easy fruit drop.



Dalili Embassy

Parents	Red sport of Delcorf
Flowering	Moderate, mid-season bloom.
Ripening time	Medium. 1 day before Summered.
Precocity	Comes slow into production.
Yield	Very low. Biennial bearing. Multiple picks recommended. Low cumulative productivity.
Storage	Till mid of November
Fruit	Cylindrical shape. Short stem. Weak mottled blush on sun exposed side. Medium fruit size. Average fruit weight 139 g. The taste is insufficient. Low fruit firmness, medium soluble solid content and high acidity.
Drawbacks	Thin skin easy bruises.
Tree growth	Low.
Disease resistance	Low susceptibility to scab, mildew and canker.

Conclusion Dalili Embassy has no commercial value under the growing conditions tested due to low yield, biennial bearing, and insufficient taste.



Aroma Fagravoll

Parents	Red sport of Aroma
Flowering	Moderate, late-season bloom.
Ripening time	Late. The same as Aroma.
Precocity	Comes fast into production.
Yield	Moderate. Biennial bearing. High cumulative productivity. Thinning required.
Storage	Till the end of January

Fruit

Flat – round shape. A shallow calyx and medium deep stem cavity. Warm red blush on 40-70 % of the fruit surface.

Very large fruit size. Average fruit weight 196 g.

The taste is very good, acid, balanced and with a good aroma, juicy. Low fruit firmness, medium soluble solid content and high acidity.

Drawbacks The fruits can get calyx rot, are susceptible to bitter pit and storage fruit rot

Tree growth Low. Spreading canopy with open angles, easy to train.

Disease resistance Tolerant to scab.

Conclusion Though Aroma 'Fagravoll' gives yield and fruit quality on the same level as Aroma, it produces more coloured fruits that are more resistant to bruising. Aroma 'Fagravoll' is recommended to grow commercially replacing standard Aroma.



Initial

Parents	Gala x Redfree
Flowering	Moderate, late-season bloom.
Ripening time	Late. 4 days after Aroma. 2 of 6 seasons harvest time later than Oct.10.
Precocity	Comes late into production.
Yield	Low except one year. Very high biennial bearing.
Storage	Till mid of November

Fruit

Triploid. cylindrical to conic and lined. Light striped blush on 30 % of the fruit surface.

Very large fruit size. Average fruit weight 200 g.

The taste is medium, fresh, juicy, crunchy and aromatic. In November fruit flesh get grainy and loose taste.

High fruit firmness, high soluble solid content and medium acidity.

Drawbacks

Tree growth Moderate. Weeping.

Disease resistance Scab resistant. Moderate sensitivity to mildew.

Conclusion Despite of very large fruits Initial has no commercial value under the growing conditions tested due medium fruit taste and short storage.



Gala Must

Parents	Red sport of Gala
Flowering	Abundant, late-season bloom.
Ripening time	Late. 3 days after Aroma. 3 of 6 seasons harvest time later than Oct.10.
Precocity	Comes fast into production.
Yield	Medium. Moderate biennial bearing.
Storage	Till January

Fruit

Round-conic with deep lined calyx cavity. Red blush on 60 % of the fruit surface.

Small fruit size. Average fruit weight 113 g.

The taste is insufficient, aromatic and bitter, dominantly sweet character. Yellowish flesh. Moderately high fruit firmness, high soluble solid content and low acidity. Very high SSC/TA ratio.

Drawbacks Calyx rot

Tree growth Moderate.

Disease resistance Susceptible to scab.

Conclusion Gala Must has no commercial value under the growing conditions tested due to low yields and insufficient fruit taste.



Creston

Parents	Golden Delicious X NJ 381049
Flowering	Moderate, mid-season bloom.
Ripening time	Late. 7 days after Aroma. 3 of 6 seasons harvest time later than Oct.10.
Precocity	Comes fast into production.
Yield	High. Biennial bearing.
Storage	Till mid of November

Fruit

Cylindrical shape with distinct lines around calyx. Weak blush with light red stripes.

Large fruit size. Average fruit weight 166 g.

The taste is good, fresh, juicy and sweet. Yellowish flesh. Medium fruit firmness, high soluble solid content and medium acidity. In November fruit get greasy and flesh get grainy.

Drawbacks Skin bruises. 'Dirty'-green-yellow fruits

Tree growth Moderate. Spreading canopy.

Disease resistance Susceptible to mildew

Conclusion Despite of high yield and good taste of fruits Creston has no commercial value under the growing conditions tested due to no attractive fruit appearance and late harvest date. Creston can be recommended to cultivate for processing purposes.



Rubinstep (Pirouette®)

Parents	Clivia x Rubin
Flowering	Abundant, mid-season bloom.
Ripening time	Late. 7 days after Aroma. 2 of 6 seasons harvest time later than Oct.10.
Precocity	Comes fast into production.
Yield	High. Biennial bearing.
Storage	Till February - March
Fruit	<p>Round-flat shape. Carmine-red blush on 60 % of the fruit surface. Ground colour yellow-orange. Medium fruit size. Average fruit weight 137 g. Thinning required to get fruit size. The taste is very good, sweet, mild acidic, and crunchy, flesh is creamy coloured. Very high fruit firmness, high soluble solid content and acidity.</p>
Drawbacks	Quite thick and hard skin.
Tree growth	Very vigorous. Upright growth in the young orchard, then spreading
Disease resistance	Tolerant to scab and mildew. Moderate sensitivity to tree canker.

Conclusion Rubinstep is recommended for commercial growing, due to high yields and excellent fruit quality.



Lotos

Parents	Otcovo x Jolana
Flowering	Moderate, mid-season bloom.
Ripening time	Late. 7 days after Aroma. 4 of 6 seasons harvest time later than Oct.10.
Precocity	Comes fast into production.
Yield	Very high. Low biennial bearing habit observed. High cumulative productivity.
Storage	Till the end of December

Fruit

Round shape. Open, green calyx cavity, with lined edge around it. Quite short stem in a shallow stem cavity. Red blush on 60 % of the fruit surface. Visible white lenticels.

Medium fruit size. Average fruit weight 149 g.

The taste is good, sweet aromatic. Medium fruit firmness, high soluble solid content and acidity. Fruit flesh is medium juicy, cream-colored. Medium thick, rough skin

Drawbacks Weak to medium branching and some bare wood.

Tree growth Moderate. Upright growth in the young orchard, then spreading, conic canopy.

Disease resistance Scab resistant. Moderate susceptible to mildew and bitter pit

Conclusion Lotos is an early winter apple. Recommended to test in commercial scale due to scab resistance, very high yields and a good taste.



Kanzi Nicoter

Parents	Gala x Braeburn
Flowering	Abundant, mid-season bloom.
Ripening time	Late. 10 days after Aroma. 3 of 6 seasons harvest time later than Oct.10.
Precocity	Comes fast into production.
Yield	High. Moderate biennial bearing.
Storage	Not evaluated due to not complete development of fruits

Fruit

Round-conic shape with lined edges around calyx cavity. Pink-red blush on 40-50 % of the fruit surface.

Medium fruit size. Average fruit weight 149 g.

The taste is moderate, crunchy, juicy with dominating acidity. Very high fruit firmness, medium soluble solid content and high acidity.

Drawbacks Fruit can get calyx rot

Tree growth Moderate

Disease resistance Susceptible to scab and tree canker.

Conclusion Kanzi has no commercial value under the growing conditions tested due to too late ripening and insufficient eatable quality every year.



Wellant	
Parents	CPRO Selection x Elise
Flowering	Abundant, late-season bloom.
Ripening time	Very late. 17 days after Aroma. 4 of 6 seasons harvest time later than Oct.10.
Precocity	Comes fast into production.
Yield	Moderate. Low biennial bearing habit observed.
Storage	Till April
Fruit	Ovoid-ellipsoid shape, though fruits can vary in size, shape and coloration. Attractive red blush on 40-70 % of the fruit surface with distinct lenticels. Russetting on calyx and stem cavity. Large fruit size. Average fruit weight 161 g. By harvest, fruits are not mature enough for consumption. After the storage the taste is very good, aromatic, sweet and appropriate acidity. High fruit firmness maintains during the storage, very high soluble solid content and moderate acidity.
Drawbacks	Sensitive to bitter pit. Fruits get russetting. Russeted fruits shrivel in the long storage.
Tree growth	Moderate. Forms blind wood. Fruit set on short side shoots
Disease resistance	Tolerant to scab. Moderately susceptible to tree canker.
Conclusion	Despite of very late harvest Wellant might be tested in commercial scale as a substitute for Karen Schneider, but only in regions with the most favourable climate.



Greenstar

Parents	Delbarestival x Granny Smith
Flowering	Moderate, late-season bloom.
Ripening time	Very late. 18 days after Aroma. 5 of 6 seasons harvest time later than Oct.10.
Precocity	Comes fast into production.
Yield	High. Moderate biennial bearing. Very high cumulative productivity.
Storage	Not evaluated due to not complete development of fruits

Fruit

Round with lined edges around calyx. Apples do not reach yellow ground colour stays green with highly visible brown lenticels.

Large fruit size. Average fruit weight 175 g.

The taste is moderate, crunchy, moderate acidic and little aroma. Very high fruit firmness maintains during the storage, high soluble solid content and moderate acidity.

Drawbacks Fruits never reached fully ripen stage on the tree.

Tree growth Low. Weak branching and some blind wood.

Disease resistance Susceptible to scab. Mildew resistant.

Conclusion Greenstar has no commercial value under the growing conditions tested due to too late ripening



Conclusions

After comprehensive studies of twenty apple cultivars, and advanced selections, following cultivars are recommended for commercial fruit production: Rubinstep, Your Choice and Aroma 'Fagravoll' replacing standard Aroma. The cultivar Blyberg is recommended for a small-scale production for road sale and amateurs gardens, and Creston is recommended for processing purposes.

Lotos is recommended to test in commercial scale, the same as Wellant but only in regions with the most favourable climate conditions.

Despite of high yield and very good fruit quality parameters, the advanced selection L II 11/30-09 has very similar fruits and the same harvest window as standard cultivar Aroma, but shorter storage and , therefore cannot replace it.

Due to low fruit quality parameters and/or lack of taste and fruit appearance following cultivars and selections are not recommended to grow in Norway: L II 3/05-09, Sonja, L II 1/08-09, NA 42-51, MA982 06059, Ritt Bjerregaard, Dalili Embassy, Initial and Gala Must.

Due to too late harvest time following cultivars and selections are not recommended to grow in Norway: Topas, Greenstar and Kanzi.

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