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Testing new apple cultivars for Norwegian growing conditions

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NIBIO Ullensvang har i perioden 2012-2019 gjennomført rettleiingsprøving av samla 11 eplesortar 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 Asfari og Elstar Boerekamp Excellent-Star® vert tilrådde til kommersiell fruktdyrking. Sorten Tiara kan dyrkast til jus og som dekorasjonsfrukt sidan den har raudt fruktkjøt. Sorten Pinova bør prøvast vidare. På grunn av svak fruktkvalitet og sein modning er fylgjande sortar og utval ikkje tilrådde for dyrking under norske tilhøve: 1/05, 58/06, A 75, Galmac, Jugala, Crimson Crisp og Elshof.

In total eleven apple cultivars, and advanced selections, were tested at NIBIO Ullensvang during 2012 – 2019. 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 Asfari and Elstar Boerekamp Excellent-Star® are recommended for commercial fruit production; cultivar Tiara is recommended for juice production and as dessert decoration element since it got pink flesh. Pinova is recommended to test additionally in commercial scale. Due to low fruit quality parameters and/or lack of taste and fruit



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appearance following cultivars and selections are not recommended to grow in Norway: Selections 1/05, 58/06, A 75, Galmac, Jugala, Crimson Crisp and Elshof.

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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 7 years.

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

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

Lofthus, 22.03.2021

Mekjell Meland

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1 Introduction

Apple growing in Norway requires thorough evaluation of new cultivars before planting them in commercial scale due to the uniqueness of climate, latitude and shorter vegetation season. Testing of cultivars grown and new releases of early ripening cultivars from different breeding programs in Europe are the main objectives at Nibio Ullensvang.

Apple cultivar trial established in 2011 at Nibio Ullensvang investigated Norwegian scab resistant cultivars and advanced selections. Apple cultivars Your Choice and Aroma 'Fagravoll' replacing the main cultivar Aroma were recommended for commercial fruit production and the cultivar Blyberg was recommended for a small-scale production for road sale and amateurs gardens (Frøyne et al., 2020).

An apple cultivar trial established in 2008 at Nibio Ullensvang included the two cultivars Greenstar and Kanzi from Better3Fruits breeding company in Belgium, (Frøyne et al., 2020). Due to too late harvest time, they were not recommended to grow in Norway However, data on their productivity and potential fruit quality were gathered and makes it interesting to test other releases from Better3Fruits (www.better3fruit.com).

The apple cultivar Gala has many mutations and is one of the most planted apples worldwide during the last two decades. Total Gala crop in Europe constantly takes second place after the Golden Delicious and still increasing its share in total apple production (data of Prognosfruit 2020 conference, www.prognosfruit.eu). Several Gala mutations are not only colour mutants but also could have different ripening time than original Gala or different fruit size and quality (Malladi and Hirst, 2010). Gala strains with these new features could be of interest for Norwegian growers.

Apple cultivar Elstar with several mutations is a very popular apple in northern part of Europe - Germany, Netherlands and Denmark (data of World apple and pear association, www.wapa-association.org). Though Elstar ripening time is on the latest limit in Norway, new mutations could have other characteristics and therefore are interesting for proper evaluation under Norwegian climatic conditions.

The aim of this reported apple cultivar trial was to investigate mutants of some apple cultivars, recently released cultivars and premium selections from European breeding programs and determine their suitability for the intensification of fruit production in Norway.

2 Materials and Methods

Planting material of tested cultivars and selections (Table 1) was grafted on M.9 rootstock and planted as one-year old whips in autumn 2012. Planting distance was 3.5 x 1 m. Each cultivar was replicated from 3 till 12 times with one tree per plot.

Table 1. Origin and parentage of cultivars and advanced selections.

Cultivar	Breeder	Country of origin	Parents
1/05	-	Italy	Not disclosed by breeder
58/06	-	Belgium	Not disclosed by breeder
Apple65 (Asfari)	Better3Fruit NV	Belgium,	Elstar x Delcorf
Galmac	Agroscope	Switzerland	Gala x Jersey mac
Jugala	Waimea Nursery	New Zealand	Early mutation of 'Mitchgla' Gala
Tiara (MA 992 48017)	Graminor	Norway	Pink Pearl x K 2-24
A 75	-	-	Not disclosed by breeder
Crimson Crisp (Co-op 39)	Purdue Research Foundation	USA	Cross between two breeding selections
Elshof	Wageningen	The Netherlands	Red mutation of Elstar
Elstar Boerekamp	Wageningen	The Netherlands	Red mutation of Elstar
Pinova	Pillnitz, Dresden	Germany	Clivia x Golden Delicious

Trees 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 cover colour (blush) was evaluated in 1-9-point scale, where 1 – 0% of blush, 9 – 100% of fruit surface is covered by red blush. 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):

$$ABI = \frac{\text{year 1 yield} - \text{year 2 yield}}{\text{year 1 yield} + \text{year 2 yield}}$$
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 seven years but yield and fruit quality parameters are presented as an average of the last five (2015-2019) years when the apple trees entered full production phase.

3 Results and Discussions

Phenology of flowering and fruit ripening. Flowering time of tested cultivars varied from early to very late (Table 2). The cultivars Tiara, 1/05 and 58/06 belonged to early flowering cultivar group, while Jugala to very late flowering group. All other tested cultivars and selections had mid to late flowering time. Flowering time was greatly dependent on the weather conditions. It varied around three weeks during seven years of observation. Similar observations were reported in a previous apple cultivar trial as well (Frøyne et al., 2020). Latest flowering date was recorded in 2013, when all cultivars reached full bloom stage beginning of June. In the 2014 and 2019 these seasons distinguished by the early flowering of all cultivars (on average 14-15 May). During the trial period the cultivars Tiara and Galmac had the shortest variation in full flowering time (17 days), while variation of 23 days was recorded for Jugala, Pinova and 58/06.

Pinova and Tiara apple trees had the most abundant flowering. The least flowering was recorded for Elstar Boerekamp and Elshof, what could be explained by their very vigorous growth and biennial bearing habit. Flowering abundance of the rest of cultivars felt in between these two cultivars.

Table 2. Flowering phenology of eleven tested cultivars, 2013-2019 at NIBIO Ullensvang

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 ¹
1/05	15-May	20-May	28-May	10-May–01-Jun	7.1 ab
58/06	15-May	20-May	28-May	09-May–01-Jun	6.5 ab
Asfari	19-May	23-May	31-May	14-May–01-Jun	6.0 ab
Galmac	19-May	23-May	31-May	15-May–01-Jun	6.7 ab
Jugala	23-May	27-May	04-Jun	18-May–10-Jun	6.6 ab
Tiara	16-May	20-May	28-May	11-28 May	7.9 a
A 75	19-May	23-May	31-May	14-May–03-Jun	6.9 ab
Crimson Crisp	20-May	24-May	01-Jun	15-May–04-Jun	6.1 ab
Elshof	21-May	25-May	02-Jun	16-May–03-Jun	5.5 b
Elstar Boerekamp	22-May	26-May	03-Jun	17-May–06-Jun	5.4 b
Pinova	18-May	22-May	30-May	13-May–05-Jun	7.9 a

¹Flowering abundance scale where 1 – no flowers, 9 – the highest possible number of flowers

Values within a column that do not share the same letter are significantly different

Table 3. Fruit harvest dates of eleven tested cultivars, 2014-2019

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)
1/05	27-Aug d	12-Aug–07-Sep	26	0
58/06	02-Sep d	15-Aug–07-Sep	23	0
Asfari	04-Sep cd	18-Aug–11-Sep	24	0
Galmac	04-Sep cd	18-Aug–16-Sep	29	0
Jugala	22-Sep bc	06-Sep–01-Oct	25	0
Tiara	22-Sep bc	03-Sep–06-Oct	33	0
A 75	25-Sep ab	06-Sep–13-Oct	35	2
Crimson Crisp	28-Sep ab	10-Sep–13-Oct	33	2
Elshof	30-Sep ab	07-Sep–11-Oct	34	2
Elstar Boerekamp	03-Oct ab	15-Sep–13-Oct	28	3
Pinova	07-Oct a	18-Sep–17-Oct	29	4

Values within a column that do not share the same letter are significantly different

According to fruit ripening and harvest time, these cultivars belong to five groups: early cultivar – 1/05 (27 Aug.), medium – early cultivars – 58/06, Asfari and Galmac (02–04 Sep), medium – late cultivars – Jugala, Tiara and A 75 (22–25 Sep), late cultivars – Crimson Crisp, Elshof and Elstar Boerekamp (28 Sep–03 Oct), and very late cultivar – Pinova (Table 3).

During the 6 observation years difference between earliest and latest harvest dates was 24 – 35 days. Difference of harvest date longer than one month was recorded for A 75, Tiara, Elshof and Crimson Crisp. Due to year effect on fruit ripening time, even 4 seasons out of 6 were too late for Pinova cultivar when fruits were harvested later than 10 Oct, 2 – 3 seasons were too late for Crimson Crisp, Elshof, A 75 and Elstar Boerekamp. Despite of these results, and taking on account global warming, all these tested cultivars could be grown at the Norwegian climate conditions.

Tree growth, yield and productivity. Elstar Boerekamp and Elshof were the most precocious cultivars and started to yield in 2013 or in the year after planting (Fig.1). The first yields of these cultivars already reached 2.8 – 3 kg/tree or 8.0 – 8.6 t/ha. Pinova and A 75 also gave a considerable first yield. However, Tiara trees were at least precocious and reached such a yield only after 3 years. Pinova had the earliest and stable increase of the yield and gave the largest cumulative yield (75.3 kg/tree) among tested cultivars and advanced selections (Table 4). Only two Elstar strains, Elstar Boerekamp and Elshof, gave comparable to it cumulative yield. All other cultivars had significantly lower yield during 7-year period. The lowest harvest was gathered from Crimson Crisp (29.8 kg/tree) and was even 2.5 times lower than one from Pinova trees. Tiara, Jugala and Asfari also had lower cumulative yields and not significant different from Crimson Crisp trees.

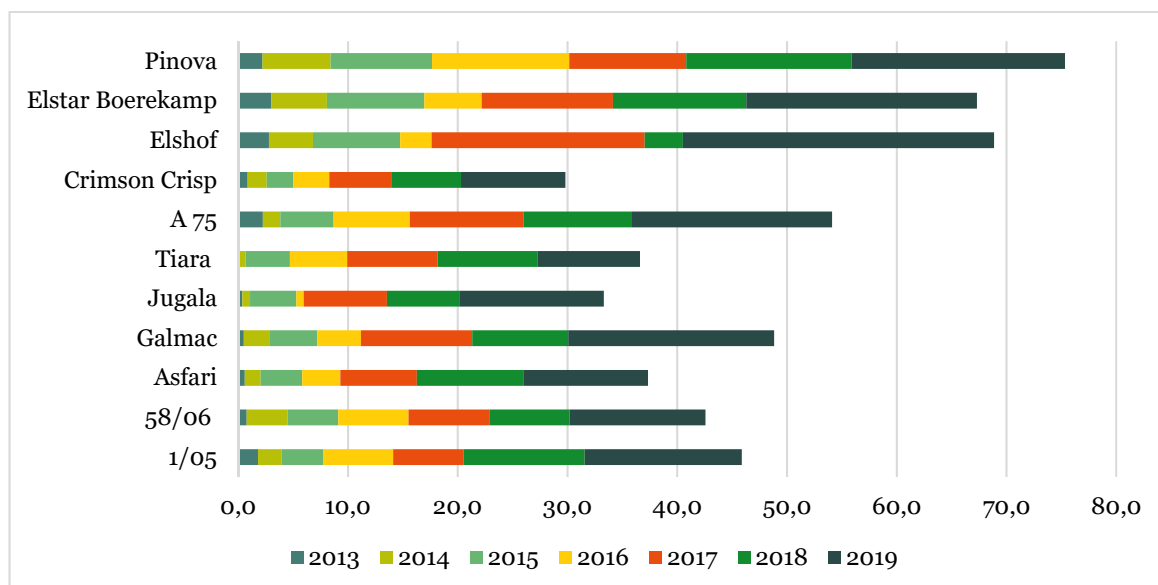


Fig. 1. Annual yield of eleven tested cultivars during the trial period, 2013-2019, kg/tree.

Elstar Boerekamp and Elshof were significantly the most vigorous cultivars. Two times or even more smaller tree trunk cross sectional area (TCSA) was recorded for the rest of tested cultivars and advanced selections. Crimson Crisp exhibited the modest growth (Table 4).

Having such differences in genotype induced tree vigour, optimisation of planting distances – broader for Elstar mutations and very dense plantations of Crimson Crisp – could be a benefit to reach the highest income from the orchard. The same goal could be reached by selection of optimal rootstock – cultivar combination.

Table 4. Trunk cross sectional area (TCSA), cumulative yield, productivity and annual bearing index (ABI) of eleven cultivars, 2013-2019.

Cultivar	TCSA, cm ²	Cumulative yield, kg tree	Cumulative productivity, kg/cm ² TCSA	ABI
1/05	13.5 bc	45.9 bc	3.40 cd	0.00 d
58/06	9.4 bc	42.6 bc	4.53 ab	0.23 c
Asfari	14.2 b	37.3 cd	2.63 e	0.00 d
Galmac	14.4 b	48.8 b	3.39 cd	0.23 c
Jugala	12.1 bc	33.3 cd	2.75 de	0.49 b
Tiara	12.1 bc	36.6 cd	3.02 de	0.00 d
A 75	12.0 bc	54.1 b	4.51 ab	0.08 d
Crimson Crisp	7.7 c	29.8 d	3.87 bc	0.00 d
Elshof	24.3 a	68.9 a	2.84 de	0.67 a
Elstar Boerekamp	26.8 a	67.3 a	2.51 e	0.23 c
Pinova	14.1 bc	75.3 a	5.34 a	0.02 d

Values within a column that do not share the same letter are significantly different

Cumulative productivity is a parameter combining yield and tree vegetative growth parameters. The higher productivity the higher ratio between yield and vegetative growth. Pinova was the most productive cultivar and only cumulative productivity of 58/06 and A 75 did not differ significantly (Table 4). Despite that Elstar Boerekamp and Elshof had the same cumulative yield as Pinova, their

tree productivity, due to very vigorous growth, was significantly lower than most of the tested cultivars.

Most cultivars increased the yields until the last year of the experiment or had very small variation between years (Fig. 1). Annual bearing index (ABI) for these cultivars was 0.00 – 0.08 (Table 4). ABI of Galmac, 58/06 and Elstar Boerekamp was very low as well and averaged 0.23. Significantly biennial bearing pattern was expressed for Jugala (0.49) and even more for Elshof (0.67) (Fig. 2).

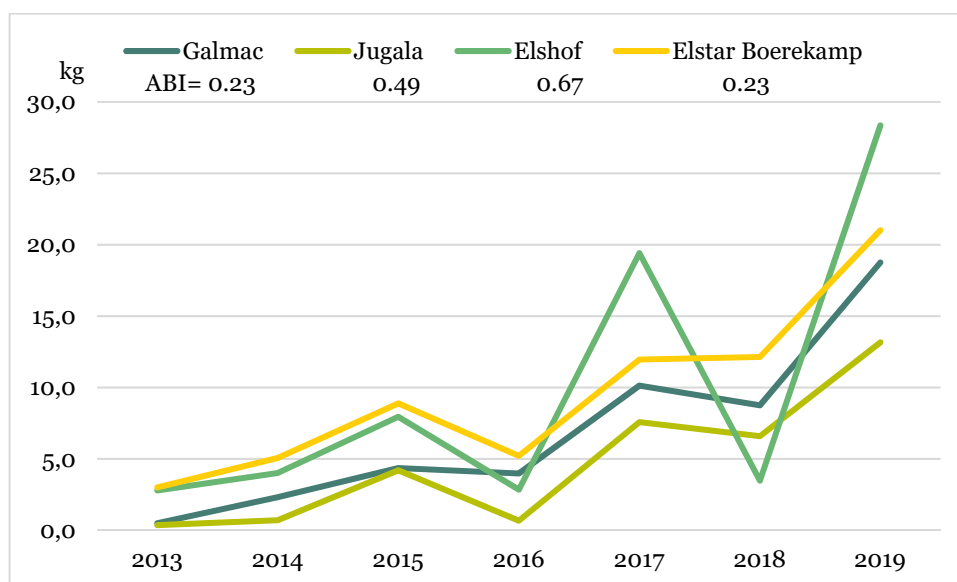


Fig. 2. Yearly cropping patterns of the cultivars with the highest alternate bearing index (ABI), kg/tree.

Maximum yield of all cultivars was reached during the last year of the experiment (Fig.3). Over 50 t/ha yield was harvested from A75, Galmac, Pinova and Elstar Boerekamp. The yield of Elshof was significantly the highest and reached over 80 t/ha. Tiara and Crimson Crisp gave the lowest yield and approximately 27 t/ha. However, during the year of the highest yield most of cultivars had smaller fruits. Especially high decrease of fruit weight was recorded for Elstar Boerekamp, Crimson Crisp, Tiara and 58/06.

Judging on the correlations between yield, number of fruits per tree and fruit weight changes, taking in account biennial bearing pattern and tree vigour, the following stable annual yields could be projected at Norwegian growing conditions: Jugala and Crimson Crisp– 20 t/ha; Tiara and 58/06 – 25 t/ha; Galmac, 1/05, A 75, Elshof and Asfari – 30 t/ha; Elstar Boerekamp – 35 t/ha and Pinova – over 40 t/ha.

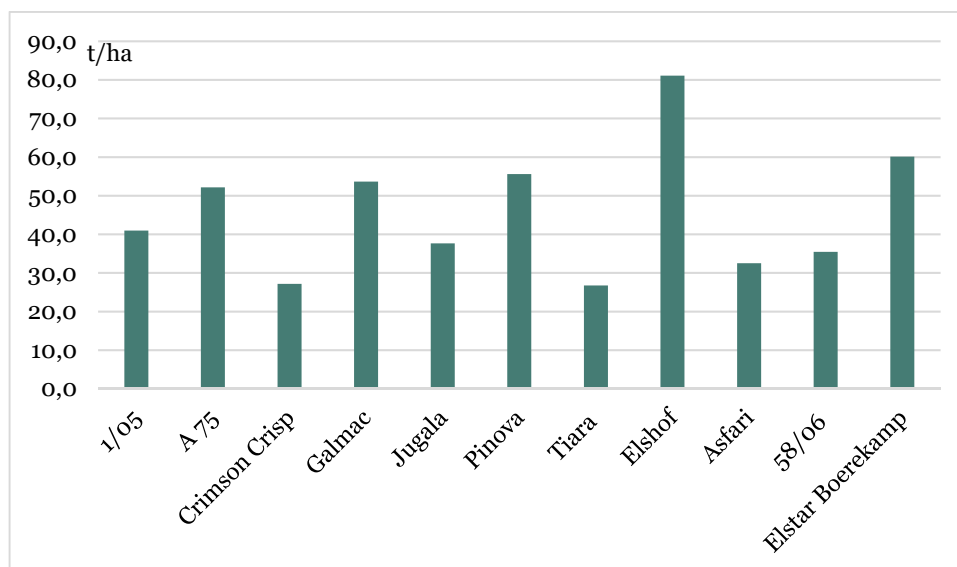


Fig. 3. Yields of 11 cultivars in the last registered year in 2019, t/ha.

Fruit quality. Average fruit weights of both Elstar mutations, Elstar Boerekamp and Elshof, were significantly higher than of most cultivars in this trial (Table 5; Fig. 3). Only one cultivar, Asfari, had comparable fruit weight. These three cultivars with the addition of Pinova had the highest percentage (94–99%) of fruits with the diameter larger than 60 mm.

Jugala average fruit weight was only 104 g and diameter of only 75% of fruits were larger than 60 mm. Another Gala colour mutant, Gala Must, which was tested in the apple cultivar trial 2008 had also the smallest fruits (Frøynes et al., 2020). Similar data for Gala fruits and its mutations are reported from other countries too (Papstein and Sedlak, 2019).

Fruit weight directly depends on the yield or number of fruits per tree in addition to the genetics of the cultivars. Differences of fruit weight between the high yield and low yield seasons could reach 40–50% for Elstar Boerekamp, Crimson Crisp, Tiara and 58/06 (Fig. 3). The same high variation was recorded both for large fruited as Elstar Boerekamp and small fruited as 58/06 cultivars. Variation of fruit weight of most other cultivars during 4 years of full cropping period felt between 20–30%. Very stable fruit weight was recorded for selection 1/05.

Elstar Boerekamp, Asfari and Elshof fruits got the highest average taste score (Table 5), Jugala and A 75 fruits were rated as lacking good taste. Sensory analysis showed that taste of all other cultivars felt between these two groups and did not differ significantly from one or another. Differences in taste scores between years and among cultivars can be explained based on different climate conditions, crop loads and interaction between these factors with the cultivars genetic properties. The most variable taste score during the trial period, was recorded for Galmac, 1/05 and Jugala cultivars.

Table 5. Average fruit weight, grading and taste evaluation of tested cultivars, average 2015-2018.

Cultivar	Average fruit weight, g	Class 1 fruits, %	Fruit colour, scale ¹	Taste ²
1/05	118 def	90	4.3 bcd	6.4 abc
58/06	111 ef	78	4.8 bcd	6.6 abc
Asfari	145 abc	99	1.4 e	7.8 a
Galmac	126 cdef	85	5.6 abc	5.6 cd
Jugala	104 f	75	6.7 ab	4.4 d
Tiara	136 bcde	84	6.9 a	5.6 cd
A 75	144 abc	96	3.3 cde	4.5 cd
Crimson Crisp	125 cdef	86	5.6 abc	5.3 cd
Elshof	159 ab	94	5.0 abc	7.6 ab
Elstar Boerekamp	161 a	96	6.4 ab	8.1 a
Pinova	135 cde	95	2.9 de	6.1 abcd

¹ Fruit cover colour (blush) 1-9-point scale, where 1 – 0% of blush, 9 – 100% of fruit surface is covered by red blush

²Fruit taste assessed in 1- 9 scale score, where 1 – uneatable, 9 – excellent taste.

Values within a column that do not share the same letter are significantly different

On average around 80% of Tiara fruit surface was covered by red blush. Other 5 cultivars – Jugala, Elstar Boerekamp, Galmac, Elshof and Crimson Crisp had less blush but not significant different from Tiara. Asfari was the only yellow fruited cultivar in this trial, although cover colour of Pinova and A 75 fruits was not significantly different. Year to year variation in fruit colouring was relatively low.

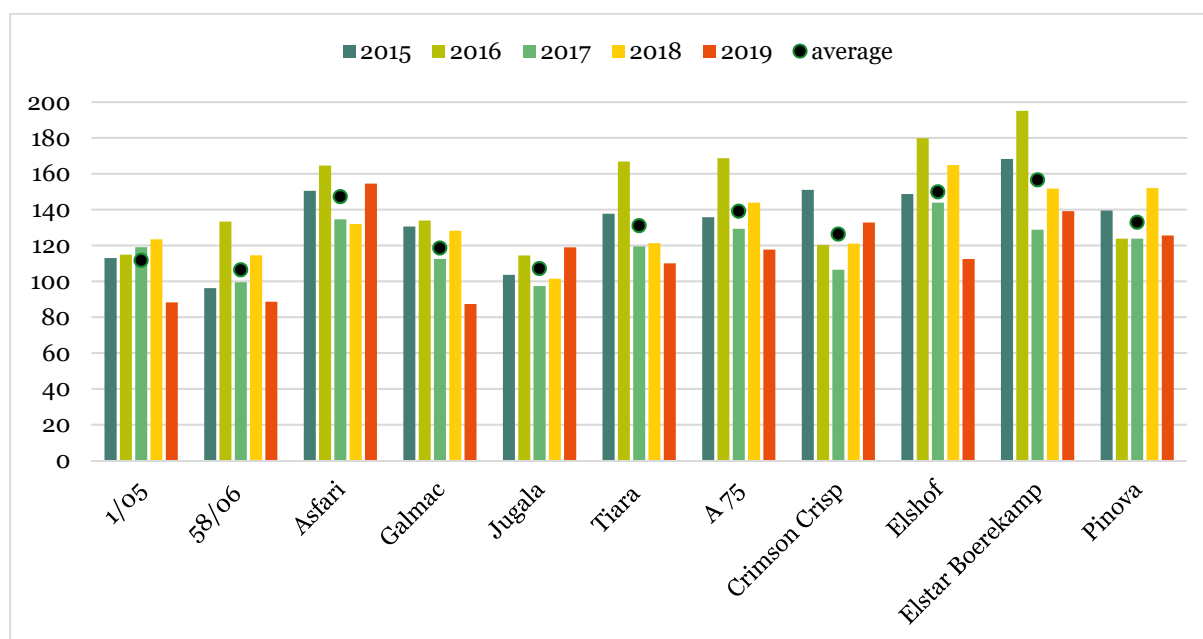


Fig. 3. Variation of fruit weights of eleven cultivars during 2015-2018 and average fruit weight, g.

Fruit firmness is one of the main factors determining overall eating and liking of apple fruits (Harker et al., 2008). In this trial Tiara had significantly the firmest fruits at harvest and together with Crimson Crisp, Pinova and Jugala after the storage (Table 6), though their taste was rated as average and in the case of Jugala as the worst. A 75, Elstar Boerekamp and Elshof had the lowest fruit firmness after the storage but still higher that is pointed to be a minimum firmness (4.7 kg cm²) for Elstar and its mutants

(Hoehn et al., 2003). Usually, fruits that keep their firmness longer have better storage ability. Cultivars 58/06, Asfari, 1/05 and Pinova had the lowest decrease (approx. 3-11%) of fruit firmness during the storage when the rest of cultivars lost their firmness around 20% and A 75 even 36%.

Table 6. Fruit firmness of eleven cultivars at harvest and after 1- month storage, kg cm²

Cultivar	Fruit firmness at harvest ¹	Fruit firmness after 1-month storage ¹	Softening rate, %
1/05	7.4 d	6.6 def	11
58/06	8.0 d	7.7 bcd	3
Asfari	7.8 d	7.0 cde	10
Galmac	7.6 d	6.2 ef	18
Jugala	10.1 b	7.9 abc	21
Tiara	11.3 a	8.8 a	22
A 75	8.3 cd	5.3 g	36
Crimson Crisp	10.4 b	8.8 a	15
Elshof	7.7 d	6.1 fg	22
Elstar Boerekamp	7.8 d	6.1 fg	23
Pinova	9.0 c	8.1 ab	11

¹ Fruit firmness (kg cm²) was measured by fruit texture digital measurer Durofel® 25 using standard probe 0,25 mm

Values within a column that do not share the same letter are significantly different

Fruit biochemical contents. Different sugars mostly determined as fruit soluble solid content (SSC) in fruits e.g. more sugars higher SSC. Endrizzi et al. (2015) stated that overall liking of apple fruits was positively influenced by high levels of sweetness. SSC of all tested cultivars was on average level. The highest content (12.4 – 13.2%) was found in Tiara, A 75, Pinova, Elstar Boerekamp and Elshof fruits at harvest time (Table 7). The fruits of the cultivars 1/05 and Crimson Crisp had significantly lower SSC. Usually during the storage SSC in apple fruits increases when starch is converted to sugars. The same procedure happened in this trial too – SSC increased during one month of storage depending on cultivar and was in the range 1 – 8.8%. After one month the highest content was found in Elstar Boerekamp fruits and only Elshof fruit did not differ much. SSC was not significant different among the rest of cultivars.

Crimson Crisp fruits had the highest amount of titratable acidity (TA). Both Elshof at harvest and Elstar Boerekamp, Pinova and A 75 after the storage did not differ. The lowest TA both at harvest and after the storage was found in Jugala, 58/06 and 1/05.

Due to very high TA and very low SSC significantly the lowest ratio SSC/TA ratio was recorded for Crimson Crisp and equalled to a ratio of sour wild apples (Jakobek et al., 2020). On another hand, very low TA determined the highest SSC/TA ratio in Jugala, 1/05 and 58/06 fruits both at harvest and after the storage. The fruit flavour of these cultivars had prevailing sweet character.

Table 7. Fruit soluble solid content (SSC), titratable acidity (TA) and SSC/TA ratio at harvest and after the 1-month storage of eleven cultivars, %, average 2013 – 2019.

Cultivar	At harvest			After 1 month storage		
	SSC	TA	SSC/TA	SSC	TA	SSC/TA
1/05	11.4 c	0.54 ef	21 ab	12.1 c	0.55 c	22 a
58/06	11.8 bc	0.58 ef	20 abc	12.3 bc	0.53 c	23 a
Asfari	12.0 bc	0.63 def	20 abc	12.8 bc	0.67 bc	19 b
Galmac	11.9 bc	0.67 cde	18 cde	11.9 c	0.67 bc	19 b
Jugala	11.8 bc	0.52 f	23 a	12.8 bc	0.59 c	23 a
Tiara	12.4 abc	0.67 cde	19 bcd	12.9 bc	0.69 bc	19 b
A 75	12.5 ab	0.75 bcd	17 de	12.7 bc	0.72 abc	18 b
Crimson Crisp	11.4 c	0.98 a	12 f	12.4 bc	0.97 a	13 c
Elshof	13.2 a	0.85 ab	16 e	13.5 ab	0.87 ab	18 b
Elstar Boerekamp	13.0 a	0.77 bc	17 de	14.2 a	0.81 abc	19 b
Pinova	12.6 ab	0.75 bcd	17 de	12.9 bc	0.72 abc	20 ab

Values within a column that do not share the same letter are significantly different

Cultivar descriptions

1/05

Parents	Not disclosed by breeder
Flowering	Abundant, early-season flowering. 2 days after Summerred
Ripening time	Early. 14 days before Summerred.
Precocity	Comes relatively fast into production.
Yield	Moderate (up to 30 t/ha) in the productive orchard. No biennial bearing observed.
Storage	Short. 5 – 6 weeks. Fruits start shrivel after few weeks
Fruit	<p>Round-obloid fruits with shallow open calyx and stem cavity with medium long stem. White ground colour, bright red blush covers 40-50% of the fruit surface. Quite small fruit size. Average fruit weight 118 g.</p> <p>The taste is medium good and turns dry. Low fruit firmness, soluble solid content and acidity.</p>
Drawbacks	Short storage. Fruit drop. Easy bruising.
Tree growth	Weak. Spreading branches.
Disease resistance	Susceptible to scab. Tolerant to tree canker.

Conclusion	Selection 1/05 has no commercial value under the growing conditions tested due to low fruit quality and taste and fruits are dropping.
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58/06

Parents	Not disclosed by breeder
Flowering	Abundant, early-season flowering. 2 days after Summerred
Ripening time	Mid – early. 9 days before Summerred.
Precocity	Comes relatively fast into production.
Yield	Low (up to 25 t/ha) in the productive orchard. Tendency to biennial bearing observed.
Storage	Till the end of October. Tendency to shrivel.

Fruit

Round-obloid fruits with shallow open calyx cavity and medium shallow stem cavity with a long stem. Bright red blush on 50 % of the fruit surface.

Small fruit size. Average fruit weight 111 g.

The taste is good, sweet with good sugar/acid balance. Medium fruit firmness, medium soluble solid content and low acidity. Low softening rate during the storage.

Drawbacks Very sensitive to russetting.

Tree growth Weak. Spreading.

Disease resistance Susceptible to scab. Tolerant to tree canker.

Conclusion Despite of good taste Selection 58/06 has no commercial value under the growing conditions tested due to small fruits, susceptibility to russetting and early shrivelling during the storage.



Galmac

Parents	Gala x Jersey mac
Flowering	Abundant, mid to late-season flowering. 5 days after Summerred
Ripening time	Mid– early. 5 days before Summerred.
Precocity	Comes slow into production.
Yield	Moderate (up to 30 t/ha) in the productive orchard. Tendency to biennial bearing observed.
Storage	Till the mid of November.

Fruit

Conic-round fruits with deep calyx cavity and medium deep stem cavity with short stem. Red to mottled blush covers 60% of the fruit surface. Nice appearance. Quite small fruit size. Average fruit weight 126 g.

The taste is average, unpleasantly sweet, very aromatic. Medium fruit firmness, soluble solid content and acidity.

Drawbacks Easy bruising.

Tree growth Weak. Spreading.

Disease resistance Susceptible to scab. Moderate susceptible to tree canker.

Conclusion Galmac has no commercial value under the growing conditions tested due to low fruit taste and easy bruising.



Asfari

Parents	Elstar x Delcorf
Flowering	Moderate, mid late-season flowering 5 days after Summerred
Ripening time	Mid– early. 6 days before Summerred.
Precocity	Comes relatively fast into production.
Yield	Moderate (up to 30 t/ha) in the productive orchard. No biennial bearing observed. Harvest in one picking.
Storage	Till January.

Fruit

Conic-round fruits with medium deep open calyx cavity and shallow stem cavity with medium short stem. Shining yellow fruits sometimes slightly red to mottled blush. Nice appearance. Medium fruit size. Average fruit weight 145 g.

Very good and mild flavour. Medium fruit firmness, soluble solid content and acidity. Low softening rate during the storage.

Drawbacks Special pruning for tip-bearer cultivars. Needs early thinning.

Tree growth Weak. Upright growth in the young orchard, later dropping. Tip-bearer.

Disease resistance Moderate susceptible to scab. Moderate susceptible to tree canker.

Conclusion Asfari is recommended for commercial growing, due to nice yellow appearance without blush, very good taste and extraordinary storing ability for its harvest time. To be a non-blushed variety, it is fairly resistant to bruising



Jugala

Parents	Early mutation of 'Mitchgla' Gala
Flowering	Abundant, very late-season flowering. 9 days after Summerred
Ripening time	Mid– late. 12 days after Summerred.
Precocity	Comes slow into production.
Yield	Very low (up to 20 t/ha) in the productive orchard. Strong biennial bearing.
Storage	Till the end of December.
Fruit	<p>Conic-ovoid fruits with medium open calyx cavity and medium deep stem cavity. Red blush covers 70% of the fruit surface. Small fruit size. Average fruit weight 104 g.</p> <p>Lack of taste, very aromatic, sweet. Firm fruits, medium soluble solid contents and low acidity.</p>
Drawbacks	Low yield, small fruits, lack of taste
Tree growth	Weak. Spreading.
Disease resistance	Susceptible to scab.

Conclusion	Jugala has no commercial value under the growing conditions tested due to low yield, small fruits and low fruit taste.
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Tiara

Parents	Pink Pearl x K 2-24
Flowering	Abundant, early-season flowering 2 days after Summerred
Ripening time	Mid– late. 9 days after Summerred.
Precocity	Comes slow into production.
Yield	Low (up to 25 t/ha) in the productive orchard. No biennial bearing observed.
Storage	Till the mid of November.

Fruit

Round, lined fruits with deep calyx cavity and shallow stem cavity with short, thick stem. Orange blush covers 80% of the fruit surface. Highly visible white lenticels. Pink flesh. Medium fruit size. On some trees very small fruits. Average fruit weight 136 g.

The taste is average, Very high fruit firmness, high soluble solid content and moderate acidity. Thick and hard peel.

Drawbacks Low yields, lack of taste, weak canopy

Tree growth Weak. Spreading.

Disease resistance Susceptible to scab and mildew. Susceptible to bitter pit

Conclusion Tiara has a special apple quality with orange peel and pink flesh. Tiara makes a nice looking, orange coloured and good tasting juice. Might have a limited market in restaurants and households as dessert decoration element if increased productivity.



Tiara sectional picture: Dag Røen, Graminor

A 75

Parents	Not disclosed by breeder
Flowering	Abundant, mid late-season flowering. 5 days after Summerred
Ripening time	Mid– late. 14 days after Summerred. 2 of 6 seasons harvest time later than Oct.10.
Precocity	Comes fast into production.
Yield	Moderate (up to 30 t/ha) in the productive orchard. No biennial bearing. Harvest in one picking.
Storage	Till the beginning of November.
Fruit	<p>Round-round, lined fruits with medium deep calyx cavity and medium deep stem cavity with short stem. Light red mottled blush covers 20-30% of the fruit surface. Medium fruit size. Average fruit weight 144 g. Weak appearance.</p> <p>The taste is average, aromatic. Low juiciness. Medium fruit firmness, high soluble solid content and acidity. Very high softening rate during the storage.</p>
Drawbacks	Weak fruit appearance, lack of taste, grainy flesh and short storage. Easy bruising.
Tree growth	Weak. Spreading.
Disease resistance	No symptoms observed.
Conclusion	A 75 has no commercial value under the growing conditions tested due to low fruit taste, short storage and easy bruising.



Crimson Crisp

Parents	Cross between two breeding selections. Previously cultivated as Co-op 39.
Flowering	Moderate, mid late-season flowering. 6 days after Summerred
Ripening time	Late. 17 days after Summerred. 2 of 6 seasons harvest time later than Oct.10.
Precocity	Comes slow into production.
Yield	Very low (20 t/ha) in the productive orchard. No biennial bearing.
Storage	Till the beginning of January.

Fruit

Ellipsoid - ovoid fruits with open shallow calyx cavity and deep stem cavity. Shiny red blush covers 60% of the fruit surface. Visible green lenticels. Quite small fruit size. Average fruit weight 125 g.

The taste is average, very aromatic. High fruit firmness, low soluble solid content and very high acidity.

Drawbacks

Tree growth	Weak. Very upright growth.
Disease resistance	Resistant to scab (Vf-gen). Susceptible to mildew.

Conclusion	Crimson Crisp has no commercial value under the growing conditions tested due to low yield, small fruits and weak fruit taste.
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Elshof

Parents	Red mutation of Elstar
Flowering	Moderate, late-season flowering. 7 days after Summerred
Ripening time	Late. 20 days after Summerred. 2 of 6 seasons harvest time later than Oct.10.
Precocity	Comes fast into production.
Yield	High cumulative yield. Biennial bearing, moderate crop load (up to 30 t/ha) in the productive orchard should be maintained.
Storage	Till March. Requires high humidity.
Fruit	<p>Round fruits with medium deep calyx cavity and shallow stem cavity with short stem. Red orange blush covers 40-60% of the fruit surface but varies from year to year. Medium-large fruit size. Average fruit weight 159 g.</p> <p>The taste is very good, slightly acid and aromatic. Low fruit firmness, relatively high softening rate during the storage, high soluble solid content and acidity. Relatively low SSC/TA ratio.</p>
Drawbacks	Not constant colouration, very high biennial bearing
Tree growth	Very strong. Spreading/ upright.
Disease resistance	Susceptible to scab and powdery mildew. Claimed to be susceptible to tree canker.
Conclusion	Despite of very good fruit taste Elshof has no commercial value under the growing conditions tested due to not constant colouration. Other Elstar mutants overcome it.



**Elstar Boerekamp
Excellent-Star®**

Parents	Red mutation of Elstar
Flowering	Moderate, late-season flowering. 8 days after Summerred
Ripening time	Late. 23 days after Summerred. 3 of 6 seasons harvest time later than Oct.10.
Precocity	Comes fast into production.
Yield	High cumulative yield. Due to biennial bearing habit, crop load up to 35 t/ha in the productive orchard should be maintained.
Storage	Till March.

Fruit

Round fruits with open medium deep calyx cavity and shallow stem cavity with thick stem. Red to dark red blush covers 70% of the fruit surface but varies from year to year. Medium-large fruit size. Average fruit weight 161 g. Russet part can occur.

The taste is very good, slightly acid, juicy and aromatic. Low fruit firmness, relatively high softening rate during the storage, high soluble solid content and acidity. Relatively low SSC/TA ratio.

Drawbacks	Biennial bearing habit.
Tree growth	Very strong. Spreading/ upright. Somewhat bushy.
Disease resistance	Susceptible to scab, powdery mildew and canker.

Conclusion Elstar Boerekamp distinguishes among other colour mutations of Elstar by excellent fruit taste and more even colouring. Elstar Boerekamp is recommended for commercial growing applying all measures to avoid biennial bearing.



Pinova

Parents	Clivia x Golden Delicious
Flowering	Abundant, mid - season flowering, 5 days after Summerred
Ripening time	Very late. 27 days after Summerred. 4 of 6 seasons harvest time later than Oct.10.
Precocity	Comes very fast into production.
Yield	Very high (over 40 t/ha) in the productive orchard.
Storage	Till the mid of February.
Fruit	<p>Conic fruits with deep, narrow calyx cavity and shallow stem cavity with long stem. Scarce red blush covers 20% of the fruit surface. Medium fruit size. Average fruit weight 135 g.</p> <p>The taste is average, but very aromatic, crisp texture. Medium fruit firmness, relatively high soluble solid content and acidity. Low softening rate during the storage.</p>
Drawbacks	Easy bruising. Uneven fruit size. Varying taste due to climate conditions. Very late harvest.
Tree growth	Weak. Dropping.
Disease resistance	Resistant to scab and mildew. Susceptible to bitter rot in cold storage.

Conclusion Pinova has potential commercial value in organic orchards due to very high annual yields. Needs testing in larger scale and development of management practices to establish even fruit quality.



4 Conclusions

After the studies of eleven apple cultivars, and advanced selections, following cultivars are recommended for commercial fruit production: Asfari and Elstar Boerekamp.

Tiara is recommended for juice production and as dessert decoration element since it got pink flesh, if productivity can be increased.

Pinova is recommended to test in commercial scale but only in regions with the most favourable climate conditions.

Despite of very good fruit taste and high yields Elshof cannot compete with other Elstar colour mutants due to not constant colouration.

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: Selections 1/05, 58/06, A 75, Galmac, Jugala and Crimson Crisp.

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