Project title:	East Malling Strawberry Breeding Club
Project number:	SF 96a
Project leader:	Adam Whitehouse, NIAB
Report:	Final report, May 2023
Previous report:	SF 96a Annual Report 2022
Key staff:	Adam Whitehouse David Simpson Katie Hopson Abi Johnson Andy Passey Kirsty McLeary
Location of project:	NIAB, East Malling
Industry Representative:	Debbie Wilson
Date project commenced:	1 June 2013
Date project completed (or expected completion date):	31 May 2023

The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Adam Whitehouse

Programme Leader (Plant Breeder)

NIAB

Signature  Date 31st May 2023

Katie Hopson

Specialist (Plant Breeder)

NIAB EMR

Signature  Date 31st May 2023

Report authorised by:

Signature ..... Date .....

[Name]

[Position]

[Organisation]

Signature ..... Date .....

CONTENTS

GROWER SUMMARY

Headline

Five selections from the East Malling Strawberry Breeding Club (EMSBC) programme were commercialised as part of this project, and were named and protected and released to the industry: 'Malling™ Allure (EM2157), 'Malling™ Vitality' (EM2464), 'Malling™ Champion' (EMR564), 'Malling™ Supreme' (EMR639), 'Malling™ Ace' (EMR796) and are available to the UK industry.

Background

The main objective of the East Malling Strawberry Breeding Club (EMSBC) was to develop and improve strawberry varieties, both June and everbearing with increased yield, larger fruit size, extended season of production and greater resistance to fungal diseases. Funding for the programme was renewed in 2013 to follow on from the first tranche of the EMSBC breeding programme which started in 2008 and that delivered the June-bearer variety Malling™ Centenary. AHDB continued to contribute to the EMSBC via project SF 96a. In 2017 it was agreed that AHDB would continue to remain a member of the EMSBC and continue funding the programme until Tranche 2 of the EMSBC terminated at the end of May 2023. In 2016, East Malling Research was acquired by NIAB Ltd., and identified as NIAB EMR before finally being referred to as NIAB from 2022 onwards. Therefore for the avoidance of confusion and for consistency all activities performed or managed at the East Malling site during the period of the project will be will be referred to as 'NIAB East Malling'.

This final report summarises the outputs from this project with particular emphasis on the EMSBC trials (June-bearer maincrop and everbearer trials) that were carried out at NIAB East Malling. Details of each of the selections that have progressed to and remain in advanced trials as well as those that have been commercialised are described in detail in the Science Section.

Summary of the project and main conclusions

Between 2013 and 2023 the EMSBC programme performed 1674 crosses, assessed over 135,300 strawberry seedlings, selected and evaluated over 1,203 lines, and identified 78 advanced selections for proceeding to growers' trials. From these selections, 13 are currently being assessed or progressed to preliminary growers' trials, and three are currently being assessed in growers' large-scale trials. A further five selections: two June-bearers (EM2157 and EM2464) and three everbearers (EMR564, EMR639 and EMR796) have been commercialised, named and protected, and released to the industry: 'Malling™ Allure' (EM2157), 'Malling™ Vitality' (EM2464), 'Malling™ Champion' (EMR564), 'Malling™ Supreme' (EMR639) and 'Malling™ Ace' (EMR796). A summary table outlining the scale of the programme (2013-23) is shown below:

Process	June-bearers	Everbearers	Totals
Crosses performed	970	704	1674
Seedlings assessed	85,391	49,914	135,305
Number of selections:			
Selected from seedlings[1]	849	480	1329
Assessed in preliminary trials at NIAB[2]	860	343	1203
Progressed to growers' trials	50	28	78
Progressed to large-scale trials	3	9	12
Progressed to commercialisation	2	3	5

Descriptions of the five selections that have been commercialised between 2013 and 2023, are shown below:

- **'Malling™ Allure** (EM2157) is a late-season June-bearer, typically fruiting seven to 10 days later than 'Malling™ Centenary' and 10 to 12 days later than 'Elsanta'. Fruit quality is very similar to 'Malling™ Centenary', with Brix levels greater than Malling™ Centenary. The berries are attractive with a uniform shape and excellent firmness scores, which is reflected in good performance

of berries in shelf-life tests. 'Malling™ Allure' has very good yield potential, with an average maincrop yield of 990 g per plant in misted tip, protected soil trials at NIAB East Malling. Observations from growers' trials also indicate it has a longer cropping profile than 'Malling™ Centenary'. Fruit size is large, averaging 68% of berries >35 mm diameter and with a high percentage Class 1 fruit, averaging 91% in EMSBC grower trials. Plants have moderate vigour in comparison with other late-season varieties, and have an upright habit allowing berries to be displayed well and picked easily. Plants have moderate susceptibility crown rot and Verticillium wilt and show moderate resistance to powdery mildew.

- **'Malling™ Vitality'** (EM2464), is an early-mid season, short-day cultivar with a similar season to 'Malling™ Centenary'. It has a moderate to high Class 1 yield (comparable to 'Malling™ Centenary'), with a high percentage of Class 1 berries (96% in NIAB EMR 2016 preliminary trial, unpublished) and >60% of fruit grading out at >35mm diameter. Plants have moderate habit and vigour (similar to 'Elsanta') and excellent fruit display with berries held on long peduncles, allowing for rapid harvesting. Disease resistance Preliminary tests at NIAB East Malling indicate intermediate resistance to Verticillium wilt, and moderate resistance to both crown rot and powdery mildew.

- **'Malling™ Champion'** (EMR564), is an early season everbearer, which produces its peak harvest in July in the UK. Berries are attractive with a regular conic shape and pleasant flavour, with firm skin and flesh and excellent storage in shelf life tests. 'Malling™ Champion' has very good yield potential, averaging over 900 grams per plant in EMSBC growers' trials. Berries can be large, averaging 24 g in EMSBC growers trials, with 62% measuring >35 mm, although berry size has been noted to go smaller under very warm conditions. The percentage of Class 1 berries produced averaged 88% in EMSBC grower trials. Plants are compact with low vigour, and berries are presented on long trusses offering easy harvesting. Tests at NIAB EMR indicate plants are resistant to crown rot and Verticillium wilt and show moderate resistance to powdery mildew

- **'Malling™ Supreme'** (EMR639), is an everbearer that has shown a similar fruiting season to 'Finesse' and 'Murano' in NIAB East Malling trials. Berries are glossy and attractive, with a regular globose-conic shape, and sweet, pleasant flavour, with a mean Brix score of 9.2º in EMSBC grower trials. Yield

and berry size are moderate to high with a mean high Class 1 yield of 838 g per plant from EMSBC grower trials with good average size (mean berry weight, 21 g on EMSBC grower trials and 60% >35 mm from NIAB East Malling preliminary trials. Plants have moderate vigour with characteristic large leaves. Based on preliminary tests at NIAB East Malling, 'Malling™ Supreme' shows resistance to crown rot and powdery mildew, and moderate resistance to Verticillium wilt.

- **'Malling™ Ace'** (EMR796), is a high-yielding everbearer (>10kg Class 1 fruit (>25mm) per linear metre, Delphy Agronomic Trials 2020, unpublished).. Fruit quality is very similar to the June-bearer cultivar 'Malling™ Centenary' with large fruit size (>70% >35mm) and excellent eating quality. Preliminary tests carried out at NIAB EMR indicate it has resistance crown rot but susceptibility to powdery mildew.

All of the above varieties are being commercialised and managed by Malling™ Fruits Ltd. Technical sheets, grower guidelines and lists of licensed propagators can be found by visiting the Malling™ Fruits website (mallingfruits.com).

Three advanced selections showed potential in both the NIAB East Malling and preliminary growers' trials between 2013 and 2022 and progressed to large-scale growers' trials where their commercial potential was assessed, three of these remain in trial and will be assessed between 2023 and 2024, to ascertain their commercialisation potential. Descriptions of these three selections is shown below:

- **EM2723** is a mid-late season June-bearer selection. It has a good yield, high percentage Class 1 fruit, attractive and sweet-tasting fruit. It is being reassessed in large-scale growers' trials in 2023/24**.**
- **EMR794** is a high-yielding, large-fruit sized everbearer that has June-bearer-like fruit quality. It has a good yield, high percentage of Class 1 fruit of excellent appearance. It will be reassessed in large-scale growers' trials in 2023.
- **EMR863** is an early high-yielding everbearer, with good fruit size and excellent flavour, with a season about 4 days later than 'Elsanta'. It has very attractive, glossy berries with a regular shape, good colour and pleasant flavour. It will be reassessed in large-scale growers' trials in 2023.

In addition, 14 new selections that were identified between 2013 and 2022 are currently being tested or progressing to preliminary growers' trials for assessment between 2023 and 2025.

Financial benefits

- Improved fruit size and fruit display combined with low percentage waste, as produced by 'Malling™ Allure' and 'Malling™ Ace', will lead to reduced picking costs.
- Improved fruit quality traits (flavour, appearance, shelf life) will increase the marketability of fruit due to widespread acceptance and approval by retailers and customers.
- Extension of the growing season using early and late season, and everbearer varieties such as 'Malling™ Vitality' (early-mid June bearer), Malling™ Allure' (late June bearer) , 'Malling™ Champion' (early everbearer) and 'Malling™ Ace' (main season everbearer), will allow growers to produce fruit economically during periods when demand is high.
- Excellent disease resistance, as demonstrated by 'Malling™ Vitality' and 'Malling™ Champion' and Malling™ Supreme', allows production with reduced pesticide applications.
- UK propagators will benefit through the opportunity to produce plants of these cultivars to satisfy demand from the UK and overseas.

Action points for growers

- 'Malling™ Allure' offers a late season June-bearing cultivar that has a high percentage of Class 1 fruit, combined with excellent fruit quality, with consistently sweet flavour.
- 'Malling™ Vitality' offers an early-mid season variety where disease resistance is paramount. It offers a well-displayed yield of glossy, uniform fruit.
- 'Malling™ Champion' is an early, generative everbearer that produces firm, unform-shaped berries that have excellent shelf-life. It also has excellent disease resistance, and provides fast picking from a compact plant, with fruit on well-displayed trusses.

- ‘Malling™ Supreme’ produces consistently sweet berries, with a moderate-high yield and excellent disease resistance.
- ‘Malling™ Ace’ is the latest everbearer variety to be released from the EMSBC programme. It has excellent yield potential, with large-fruit size and June-bearer like fruit quality. It is known to be susceptible to powdery mildew, but advice on prevention and control with this variety can be found on the mallingfruits.com website.
- All of the released varieties above are being commercialised by Malling™ Fruits Ltd on behalf of the EMSBC. Technical information, grower guidelines and list of licenced propagators can be found on the Malling™ Fruits website: mallingfruits.com
- ADHB-levy payers had the opportunity to sample and discuss advanced selections and released varieties from the EMSBC programme at annual AHDB-organised growers’ walk at NIAB East Malling, Kent in June of each year of the project.

SCIENCE SECTION

Introduction

The EMSBC was set up in 2008 to continue the national strawberry programme that has operated at East Malling since 1983 with the AHDB contributing via project SF 96. A second tranche of the EMSBC was agreed in 2013 for a 10-year term (with a break clause after five years) and commenced on 1 June 2013. In 2017 the AHDB agreed to remain a member of the EMSBC and continue part funding the programme until 2023 via project SF 96a.

It was the intention of the breeding programme to release new varieties which show advantage over those currently available for a particular purpose or slot in the season. This advantage may be in terms of fruit quality, yield, resistance to diseases, fruit size and display (to reduce picking costs) and any combination of these characters.

In addition the programme is benefiting from associated research projects funded at NIAB East Malling that feed into the breeding work, primarily those associated with the development of a molecular genetics approach to disease resistance. The integration of basic science to benefit the programme has recently been demonstrated by the use of predictive scores for disease susceptibility based on genotyping of all selections and parental lines.

Materials and methods

Crossing programme

During the course of the project, an annual crossing programme was completed during February-April in controlled glasshouse conditions (22-22°C/15-17°C day/night, 16hr supplementary lighting) at NIAB East Malling. Details of the type and number of crosses made each year are shown in Table 1.

Seedling selection

In 2013 there was a pipeline of material from the previous programme comprising seedling populations of both June-bearer and everbearers. June-bearer seedling populations were raised from seed in May following the annual crossing programme and planted into fumigated (chloropicrin) raised beds in an open field between late-July and early August of each year. Everbearer seedling populations were raised annually in June, overwintered in a non-heated, vented polytunnel and planted out into fumigated (chloropicrin) raised beds in an open-field between late-March and early-April. From 2019 a proportion (c. 2500) of each seedling population (both June-bearer and everbearer were assessed in substrate (Botanicoir Precision) , table-top systems under Spanish-style polytunnels. These seedlings were planted at the same time as the soil-assessed seedlings, but at a density of four plants per metre.

The June-bearer seedling populations were assessed weekly between May and July of each year, while the everbearer seedlings were de-blossomed in mid-May and assessed weekly between July and September. Seedlings displaying a combination of desirable traits associated with fruit quality, yield, fruit size, plant architecture and disease-resistance were selected for assessment in preliminary trials at NIAB East Malling. The number of seedlings assessed between 2013 and 2022 (assessments made in 2023 were after the termination date of the current project) are shown in Table 2.

Preliminary trials (EMR)

All the preliminary trials from 2013 to 2019 were performed on the Ditton Rough soil plot (sandy loam soil), and from 2020 onwards these were then performed in substrate (coir) on table-tops on the Church Fields East plot, both at NIAB East Malling, New Road, East Malling, Kent, ME19 6BJ. The soil trials were planted as double rows at 0.6 m spacing into fumigated raised beds with polythene mulch and trickle irrigation, with 10 plants per plot. These beds were covered prior to flowering with polythene clad tunnels for rain protection and also with netting against bird damage. The substrate trials were planted into 1m bags (Botanicoir) at a density of eight tray (250cc module) plants per 1m bag for June-bearers and six mini-tray (125cc module) plants for everbearers. The substrate trials were maintained on table-top structures, under Haygrove Pioneer tunnels and irrigated using an automatic irrigation system coupled to Delta-T sensors. Each trial was maintained for a single cropping season and a

standard commercial spray programme was used to control pests and diseases. Agronomy, including fertigation and integrated pest management programmes were provided by an industry agronomist. All plots were covered by polythene clad tunnels for rain protection and netting for bird protection and from 2020 onwards insect netting on the tunnel ends.

Maincrop (June-bearer) trial

The maincrop trials contained between 68-106 new selections, up to 16 advanced selections, and at least four standards and were established from misted tips struck in mid-late June under mist, and planted at the end-July through to August for 2013-2019. From 2019, misted tips were transplanted to 250cc modules (tray plants) at the end-July (instead of being planted into the soil) and grown on until dormant and then transferred to a -2°C cold-store in December-March of each year, and then removed to be planted March into substrate (coir) from 2020 onwards (Table 3.a.). From 2020 onwards, each plot consisted of eight plants per metre, with at least two replicates per selection.

Everbearer trial

From 2013-2018 plants were propagated as misted tips at the end of July, potted on after 8 weeks into 9cm pots and then over-wintered in a polythene clad tunnel, and from 2019 onwards (for 2020 trial) plants were propagated as mini-tray (125cc modules) plants in July of each year and overwintered as in previous years. Each trial was planted during the period from late-March to early April of the following year (Table 3.b.) and from 2013-2019 these were as 10-plant plots on fumigated (chloropicrin) raised beds with opaque polythene mulch and trickle irrigation, and from 2020 onwards as six-plant plots in one metre substrate (coir) bags with at least two replicates per selection.

Plants were de-blossomed during the third week of May of each year and harvesting began at the end of June and continued twice weekly until the end of September.

The everbearer trials contained between 24 and 45 new selections, up to seven advanced selections, and at least four standards (Table 3.b).

Table 1. Number of crosses by year (2014*-2023)

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	**Totals**
June-bearer (Early)	21	28	29	39	38	25	37	46	44	23	**330**
June-bearer (Mid)	59	59	50	36	30	67	48	55	48	18	**470**
June-bearer (Late)	12	19	18	21	20	21	17	18	19	5	**170**
Everbearer	50	58	48	57	62	63	60	80	97	129	**704**
Totals	**142**	**167**	**145**	**153**	**150**	**176**	**162**	**199**	**208**	**175**	**1674**

*crosses made in 2013 are excluded as these were carried out under EMSBC Tranche 1 funding

Table 2. Number of seedlings assessed and selections by year (2013-22*) in the NIAB East Malling seedling plot

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	**Totals**
June-bearer	8,133	8.094	8,245	9,717	9,154	8,313	7,979	8,271	8,603	8,882	**85,391**
Everbearer	3,516	5,180	4,268	5,847	3,683	5,446	4,529	5,125	5,649	6,671	**49,914**
Totals	**11,649**	**13,274**	**12,513**	**15,564**	**112,837**	**13,759**	**12,508**	**13,396**	**14,252**	**15,553**	**135,305**

*Seedlings for the 2023 seedling populations were planted during the project period, but will be assessed following the termination of Tranche 2 and so have not been included in the totals

Table 3.a. Planting dates and number of new and advanced selections assessed in the NIAB East Malling June-bearer maincrop trial, 2013-22*.

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	**Totals**
Planting date	*28 Aug 12*	*30 Jul 13*	*31 Jul 14*	*4 Aug 15*	*9 Aug 16*	3 Aug 17	6 Aug 18	11 Mar 20	17 Mar 21	9 Mar 22	
New selections	94	87	86	89	87	106	75	94	68	74	**860**
Advanced selections	7	9	13	16	13	5	7	9	9	11	**99**
Totals	**101**	**96**	**99**	**105**	**100**	**111**	**82**	**103**	**77**	**85**	**959**

*Selections for the 2023 trials were planted in Spring 2023 but will be assessed after the termination date of EMSBC Tranche 2 and so have not been included in the totals

Table 3.b. Planting dates and number of new and advanced selections assessed in the NIAB East Malling everbearer trial, 2013-22*.

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	**Totals**
Planting date	*20 Mar 13*	*1 Apr 14*	*31 Mar 15*	*13 Apr 16*	28 Mar 17	27 Mar 18	18 Apr 19	1 Apr 20	31 Mar 21	6 Apr 22	
New selections	28	37	45	36	24	39	35	28	27	44	**343**
Advanced selections	4	6	2	5	6	4	7	5	5	5	**49**
Totals	**28**	**43**	**47**	**41**	**30**	**43**	**42**	**33**	**32**	**49**	**392**

*Selections for the 2023 trials were planted in Spring 2023 but will be assessed after the termination date of EMSBC Tranche 2 and so have not been included in the totals

Fruit and plant assessments (NIAB East Malling trials)

Fruit was harvested twice-weekly from each trial into individual trays that were assigned a unique alpha-numeric plot code (to avoid selection bias). Fruit was graded into five categories, primarily based on fruit size (diameter in mm): giant (>45 mm), large (>35 mm), medium (>28 mm), small (<28 mm) and waste (fruit rendered unmarketable due to damage (physical and/or pathological), misshape or rots. Class 1, or marketable fruit, was classified as fruit >28 mm diameter, with unmarketable being defined as <28 mm diameter and waste fruit.

Fruit quality (appearance, skin and flesh firmness and flavour) assessments were performed immediately after each pick, using the scoring system shown in Appendix I. Assessments were carried out by a panel of experienced breeders.

Post-harvest records of Brixº (soluble sugars) and shelf-life, were taken as often as possible throughout the season with a minimum of three records for each selection per season.

Brixº was measured using a sample of two berries per selection per pick that were halved longitudinally with the juice from each half-fruit being assessed using a digital refractometer. The mean score for each selection across the season are presented in the results section.

Shelf-life tests were performed on ten unblemished fruit that were sampled once a week for each selection during its fruiting season. Samples were collected at the fruit evaluation stage immediately after picking and were transferred in open, 454 g punnets to a +2 ºC cold-store for 24 h. After 24 h these samples were transferred to a controlled environment cabinet and maintained at 17 ºC at 70% RH for a further 72 h. An assessment of each sample was then performed via a comparative assessment against a standard cultivar using the scoring system

Growers' trials

The EMSBC members were presented with trial data from the maincrop June-bearer trial at a Board meeting in June, and everbearer trial data in August of each year. They collectively agreed which selections should progress to preliminary trials on commercial farms. These trials were organised by EMSBC members, typically at a minimum of five sites. Replicated plots were planted using 60 plants per selection on each site and included assessment as both 60-day and maincrop plantings.

The data from these trials, in conjunction with the data gathered at NIAB East Malling, was considered by EMSBC members at meetings in August and October of each year that the preliminary growers' trials were assessed. A decision was then made on how each advanced selection should progress. The options for each selection were to: reject (no further trials), proceed to large-scale growers' trials (maximum of 2,500 plants at two to three commercial farms) or fast-track to commercialisation.

Trials were performed at the Breeders' trial site (Churchfields East, East Malling, ME19 6BJ). Both trials were maintained on table tops under Haygrove Pioneer tunnels using an automatic irrigation system using Delta-T sensors. Agronomy, including fertigation and integrated pest management programmes were provided by an industry agronomist.

Fruit was harvested twice-weekly from each trial into individual trays that were assigned a unique alpha-numeric plot code (to avoid selection bias). Fruit was graded into five categories, primarily based on fruit size (diameter in mm): giant (>45 mm), large (>35 mm), medium (>28 mm), small (<28 mm) and waste (fruit rendered unmarketable due to damage (physical and/or pathological), misshape or rots. Class 1, or marketable fruit, was classified as fruit >28 mm diameter, with unmarketable being defined as <28 mm diameter and waste fruit. Yield is presented as the mean of all plants in each individual plot.

Fruit quality (appearance, skin and flesh firmness and flavour) assessments were performed immediately after each pick, using the scoring system shown in Appendix I. Assessments were carried out by a panel of experienced breeders.

Post-harvest records of Brix^{o} (soluble sugars) and shelf-life, were taken as often as possible throughout the season with a minimum of three records for each selection per season.

Brix^{o} was measured using a sample of two berries per selection per pick that were halved longitudinally with the juice from each half-fruit being assessed using a digital refractometer. The mean score for each selection across the season are presented in the results section.

Shelf-life tests were performed on ten unblemished fruit that were sampled once a week for each selection during its fruiting season. Samples were collected at the fruit evaluation stage immediately after picking and were transferred in open, 454 g punnets to a +2 ^{o}C cold-store for 24 h. After 24 h these samples were transferred to a controlled environment cabinet and maintained at 17 ^{o}C at 70% RH for a further 72 h. An assessment of each sample was then performed via a comparative assessment against a standard cultivar using the scoring system shown in the Appendix 1. The mean scores for each selection across the season are presented in the results section.

Results

Maincrop (June-bearer) trials

A total of 860 new selections were trialled in the maincrop June-bearer trial at NIAB East Malling between 2013 and 2022 (excluding 2023 trials which were planted in 2022 but will be assessed beyond the termination date of EMSBC Tranche 2 contract). Of these, 50 selections were identified for progression to preliminary growers' trials following the results of the NIAB East Malling trials. However, 38 of these advanced selections (Table 4) were subsequently deselected by the Club Board as they were subsequently found to be either susceptible to disease and/or poorly adapted to commercial growing systems (poor plant habit, low yield, and/or inferior fruit quality). Of the 12 remaining advanced selections, five (EM2836, EM2903, EM2910, EM2925, EM2933) are currently being assessed in preliminary growers' trials (2023), with another four (EM2995, EM2998, EM3007, EM3052) being propagated for assessment in 2024/25. A single selection remains in large-scale growers' trials and will be assessed in 2023-24 (EM2723). Additionally two selections (EM2157 and EM2464) were fast-tracked to commercialisation and release. EM2157 has subsequently been

released (2019) as ‘Malling™ Allure’, while EM2464 has been released (2021) as ‘Malling™ Vitality’. Both these released varieties are being commercialised by Malling™ Fruits Ltd (mallingfruits.com). The status of all the advanced selections that were identified between 2013 and 2022 (Table 4), along with descriptions of those selections that have progressed to large-scale growers’ trials or have been released. Detailed tables showing performance against standards can be found in the respective AHDB Annual Trial Reports for each trial year.

Table 4. The current status of advanced Jun-bearer selections that were identified and trialled between 2013 and 2022. Descriptions of those shown in **BOLD** appear below the table.

Selection	Year in trial		Current status
	NIAB EM	Grower[1]	
EM2290	2013	2015-16	Rejected 2016 following growers' maincrop trials
EM2298	2013	2015-16	Rejected 2016 following growers' maincrop trials
EM2299	2013	2015-16	Rejected 2015 following growers' 60-day trials
EM2301	2013	2015-16	Rejected 2016 following growers' maincrop trials
EM2315	2013	2015-16	Rejected 2016 following growers' maincrop trials
EM2320	2013	2015-16	Rejected 2016 following growers' maincrop trials
EM2157	**2014**	**2016-17**	**Released as 'Malling™ Allure' in 2019**
EM2192	2014	2016-17	Rejected 2017 following growers' maincrop trials
EM2206	2014	2016-17	Rejected 2016 following growers' 60-day trials
EM2358	2014	2016-17	Rejected 2016 following growers' 60-day trials
EM2199	2015	2017-18	Rejected 2018 following growers' maincrop trials
EM2379	2015	2017-18	Rejected 2017 following growers' 60-day trials
EM2380	2015	2017-18	Rejected 2018 following growers' maincrop trials
EM2421	2015	2017-18	Rejected 2018 following growers' maincrop trials
EM2448	2016	2018-19	Rejected 2018 following growers' maincrop trials
EM2464	**2016**	**2018-19**	**Released as 'Malling™ Vitality in 2021**
EM2483	2016	2018-19	Rejected 2019 following growers' 60-day trials
EM2494	2016	2018-19	Rejected 2019 following growers' maincrop trials
EM2248	2017	2019-20	Rejected 2019 following growers' 60-day trials
EM2434	2017	2019-20	Rejected 2019 following growers' 60-day trials
EM2541	2017	2019-20	Rejected 2019 following growers' 60-day trials
EM2544	2017	2019-20	Rejected 2019 following growers' 60-day trials
EM2588	2017	2019-20	Rejected 2019 following growers' 60-day trials
EM2622	2017	2019-20	Rejected 2019 following growers' large-scale trials
EM2547	2018	2020-21	Rejected 2020 following growers' 60-day trials
EM2591	2018	2020-21	Rejected 2019 following growers' 60-day trials
EM2617	2018	2020-21	Rejected 2019 following growers' 60-day trials

Table 4 cont. The current status of advanced Jun-bearer selections that were identified and trialled between 2013 and 2022. Descriptions of those shown in **BOLD** appear below the table.

Selection	Year in trial		Current status
	NIAB EM	Grower[1]	
EM2628	2019	2021-22	Rejected 2019 following growers' maincrop trials
EM2656	2018	2020-21	Rejected 2020 following growers' 60-day trials
EM2674	2018	2020-21	Rejected 2020 following growers' 60-day trials
EM2696	2018	2020-21	Rejected 2021 following growers' maincrop trials
EM2721	2018	2020-21	Rejected 2021 following growers' maincrop trials
EM2723	**2018**	**2020-21**	**Currently in large-scale growers' 60-day trials 2023**
EM2583	2019	2021-22	Rejected 2021 following growers' 60-day trials
EM2625	2019	2021-22	Rejected 2021 following growers' 60-day trials
EM2763	2019	2021-22	Rejected 2021 following growers' 60-day trials
EM2770	2019	2021-22	Rejected 2022 following growers' maincrop trials
EM2797	2019	2021-22	Rejected 2022 following growers' maincrop trials
EM2818	2020	2022-23	Rejected 2022 following growers' 60-day trials
EM2836	2020	2022-23	Currently in preliminary growers' maincrop trials 2023
EM2859	2020	2022-23	Rejected 2022 following growers' 60-day trials
EM2883	2020	2022-23	Rejected 2022 following growers' 60-day trials
EM2903	2021	2023-24	Currently in preliminary growers' 60-day trials 2023
EM2910	2021	2023-24	Currently in preliminary growers' 60-day trials 2023
EM2925	2021	2023-24	Currently in preliminary growers' 60-day trials 2023
EM2933	2021	2023-24	Currently in preliminary growers' 60-day trials 2023
EM2995	2022	2024-25	Progressed to preliminary growers' trials in 2024
EM2998	2022	2024-25	Progressed to preliminary growers' trials in 2024
EM3007	2022	2024-25	Progressed to preliminary growers' trials in 2024
EM3052	2022	2024-25	Progressed to preliminary growers' trials in 2024

[1]Preliminary growers' trials (60-day/main crop)

Only one June-bearer selection, EM2723 is currently in large-scale trials, a description of this, along with the two selections (EM2157 and EM2464) that have been commercialised are shown below:

EM2157, released as **Malling™ Allure** (late season June-bearer)

A late-season June-bearer, typically fruiting seven to 10 days later than 'Malling™ Centenary' and 10 to 12 days later than 'Elsanta'. Fruit quality is very similar to 'Malling™ Centenary', with Brix levels greater than Malling™ Centenary. The berries are attractive with a uniform shape and excellent firmness scores, which is reflected in good performance of berries in shelf-life tests. 'Malling™ Allure' has very good yield potential, with an average maincrop yield of 990 g per plant in misted tip, protected soil trials at NIAB East Malling. Observations from growers' trials also indicate it has a longer cropping profile than 'Malling™ Centenary'. Fruit size is large, averaging 68% of berries >35 mm diameter and with a high percentage Class 1 fruit, averaging 91% in EMSBC grower trials. Plants have moderate vigour in comparison with other late-season varieties, and have an upright habit allowing berries to be displayed well and picked easily. Plants have moderate susceptibility crown rot and Verticillium wilt and show moderate resistance to powdery mildew. EM2157 released as Malling™ Allure in 2019.

Figure 1. Fruit of Malling™ Allure (EM2157)

EM2464, released as **Malling™ Vitality** (early-mid-season June-bearer)

An early-mid season, short-day cultivar with a similar season to 'Malling™ Centenary'. It has a moderate to high Class 1 yield (comparable to 'Malling™ Centenary'), with a high percentage of Class 1 berries (96% in NIAB EMR 2016 preliminary trial, unpublished) and >60% of fruit grading out at >35mm diameter. Plants have moderate habit and vigour (similar to 'Elsanta') and excellent fruit display with berries held on long peduncles, allowing for rapid harvesting. Disease resistance Preliminary tests at NIAB East Malling indicate intermediate resistance to Verticillium wilt, and moderate resistance to both crown rot and powdery mildew.

Figure 2. Fruit of Malling™ Vitality (EM2464)

EM2723 (midseason June-bearer)

A mid-late season June-bearer moderately-high yield (869g/plant, autumn planted misted tips), with a high percentage of Class 1 fruit (89%), and fruit size similar to Malling™ Centenary (>35 mm: 61%). Berries were very attractive, with a regular colour and shape, but with slightly sunken seeds and 'pinched in' noses. Sensory flavour scores were consistently good, with a high average Brixº score (9.0º). Funders who sampled the fruit commented on its sweet, sometimes peachy flavour. Shelf-life scores were comparable to the standards, but berries sometimes lost their gloss in storage. The 50% harvest date was similar to 'Elsanta', but with a slightly extended season. Plants had moderate vigour, but there was some purple discolouration on a few of the leaves.

EM2723 progressed to preliminary growers' trials in 2020 and 2021 and then large-scale growers' trials in 2023 and 2024**.**

Figure 3. Fruit of EM2723

Everbearer trial

Twenty-eight selections in total were identified for progression to growers' trials following the results of the preliminary NIAB East Malling trials. However, 20 of these advanced selections were subsequently deselected by the Club Board as they were subsequently found to have deleterious traits that made unsuitable commercial production. Three advanced selections (EMR954, EMR985, EMR992) are currently in the process of being propagated for preliminary growers' trials in 2024, with two others (EMR74, EMR863) currently to large-scale growers' trials in 2023. A further three selections (EMR564, EMR639, EMR796) were selected for fast tracking and commercialisation due to their excellent fruit quality. EMR564 has subsequently been released as 'Malling™ Champion' (2019), EMR639 has been released as 'Malling™ Supreme' (2019) and EMR796 as 'Malling™ Ace' (2021). The current status of all the advanced selections that were identified between 2013 and 2022 are shown in Table 5, followed by descriptions of those selections that remain that are in large-scale trials or that have been released as commercial varieties. Detailed tables showing performance against standards can be found in the respective AHDB Annual Trial Reports for each trial year.

Table 5. The current status of advanced everbearer selections that were identified and trialled between 2013 and 2022. Descriptions of those shown in **BOLD** appear below the table.

Selection	Year in trial		Current status
	NIAB EM	Grower[1]	
EMR564[2]	**2011**	**2013**	**Released as 'Malling™ Champion' in 2019**
EMR612	2013	2015	Rejected 2015 following growers' trials
EMR639	**2013**	**2015**	**Released as 'Malling™ Supreme' in 2019**
EMR635	2014	2016	Rejected 2018 following large-scale growers' trials
EMR644	2014	2016	Rejected 2016 following growers' trials
EMR645	2014	2016	Rejected 2016 following growers' trials
EMR647	2014	2016	Rejected 2016 following growers' trials
EMR688	2015	2017	Rejected 2017 following growers' trials
EMR693	2015	2017	Rejected 2019 following large-scale growers' trials
EMR701	2015	2017	Rejected 2017 following growers' trials
EMR704	2015	2017	Rejected 2022 following large-scale growers' trial
EMR710	2015	2017	Rejected 2017 following growers' trials
EMR721	2016	2018	Rejected 2020 following large-scale growers' trials
EMR722	2016	2018	Rejected 2018 following growers' trials
EMR773	2017	2019	Rejected 2019 following growers' trials
EMR794	**2017**	**2019**	**Currently in large-scale growers' trials 2023**
EMR797	2017	2019	Rejected 2019 following growers' trials
EMR727	2018	2020	Rejected 2020 following growers' trials

Table 5 cont. The current status of advanced everbearer selections that were identified and trialled between 2013 and 2022. Descriptions of those shown in **BOLD** appear below the table.

Selection	Year in trial		Current status
	NIAB EM	Grower[1]	
EMR745	2018	2020	Rejected 2020 following growers' trials
EMR796	**2018**	**2020**	**Released as 'Malling™ Ace' in 2021**
EMR862	2019	2021	Rejected 2021 following growers' trials
EMR863	**2019**	**2021**	**Currently in large-scale growers' trials 2023**
EMR919	2020	2022	Rejected 2022 following growers' trials
EMR925	2020	2022	Rejected 2022 following growers' trials
EMR943	2021	2023	Currently in preliminary growers' trials in 2023
EMR965	2021	2023	Currently in preliminary growers' trials in 2023
EMR954	2022	2024	Progressed to preliminary growers' trials in 2024
EMR985	2022	2024	Progressed to preliminary growers' trials in 2024
EMR992	2022	2024	Progressed to preliminary growers' trials in 2024

[1]Preliminary growers' trials

[2]Trialled at NIAB East Malling in Tranche 1 but released during Tranche 2

A description from the NIAB East Malling preliminary trials for each of the advanced selections that are in large-scale commercial trials follows (in alphanumeric order):

EMR794

EMR794 produced the second highest Class 1 yield in trial in 2017, with a high percentage of large fruit (75% >35mm). The percentage of Class 1 fruit was relatively high (78%), with mark outs being attributed predominantly to misshape and rots. Fruit was glossy, with a bright, orange-red skin colour, but with pale flesh. The calyx was reflexed, and the seeds were sunken and shape could be a little uneven, with some knobbly fruit noted on some occasions. Berries were very firm, with a crunchy texture, but were still juicy and had a watery, sometimes sweet flavour. Brix scores were variable but on average (8.5º) and better than the standards. Shelf-life was similar to the standards, and fruit was noted as retaining its glossy appearance. Plants were uneven in the plot, but generally had moderate vigour with good fruit display. Although plants were disease free, calcium tip burn was noted on both the plants and fruit calyx.

Figure 4. Fruit of EMR794

EMR863

A very high yielding selection (964 g/plant) when trialled in 2019, with excellent fruit size (67%>35 mm) and very high percentage Class 1 (88%). Fruit quality scored very highly, standing out well in the punnet and on the plant for its glossy, uniform conic appearance. Its scores dropped only temporarily during a particularly hot period of the season, where colouration suffered slightly and became a little uneven. Sensory flavour was often described as sweet, but sometimes watery but overall EMR863 had a good average Brixº scores with a mean of 7.8º comparable, to Murano's average of 7.6º for this trial. Skin strength results throughout the season were strong with flesh firmness slightly softer. Fifty percent pick date came early in the season, however,

production continued steadily throughout the season, with only one noticeable drop in production in week 30, which mirrored the standards (Figure 7.b.). For the majority of the season, the plants were clean and healthy, but towards the end of the season, mildew was noted on a few of the berries and runners. EMR863 is yet to undergo any pathogen screening; however, predictive scoring suggests that this selection may have intermediate to moderate resistance to crown rot.

Figure 5. Fruit of EMR863

EMR564, released as **Malling™ Champion**

An early season everbearer, which produces its peak harvest in July in the UK. Berries are attractive with a regular conic shape and pleasant flavour, with firm skin and flesh and excellent storage in shelf life tests. 'Malling™ Champion' has very good yield potential, averaging over 900 g per plant in EMSBC growers' trials. Berries can be large, averaging 24g in EMSBC growers trials, with 62% measuring >35 mm, although berry size has been noted to go smaller under very warm conditions. The percentage of Class 1 berries produced averaged 88% in EMSBC grower trials. Plants are compact with low vigour, and berries are presented on long trusses offering easy harvesting. Tests at NIAB EMR indicate plants are resistant to crown rot and Verticillium wilt and show moderate resistance to powdery mildew. EMR564 released as Malling™ Champion in 2019.

Figure 6. Fruit of 'Malling™ Champion'

EMR639, released as **Malling™ Supreme**

An everbearer that has shown a similar fruiting season to 'Finesse' and 'Murano' in NIAB East Malling trials. Berries are glossy and attractive, with a regular globose-conic shape, and sweet, pleasant flavour, with a mean Brix score of 9.2º in EMSBC grower trials. Yield and berry size are moderate to high with a mean high Class 1 yield of 838 g per plant from EMSBC grower trials with good average size (mean berry weight, 21 g on EMSBC grower trials and 60% >35 mm from NIAB East Malling preliminary trials. Plants have moderate vigour with characteristic large leaves. Based on preliminary tests at NIAB East Malling, 'Malling™ Supreme' shows resistance to crown rot and powdery mildew, and moderate resistance to Verticillium wilt.. EMR639 released as Malling™ Supreme in 2019.

Figure 7. Fruit of Malling™ Supreme (EMR639)

EMR796, released as **Malling™ Ace**

An everbearer is a high-yielding everbearer (>10kg Class 1 fruit (>25mm) per linear metre, Delphy Agronomic Trials 2020, unpublished).. Fruit quality is very similar to the June-bearer cultivar 'Malling™ Centenary' with large fruit size (>70% >35mm) and excellent eating quality. Preliminary tests carried out at NIAB EMR indicate it has resistance crown rot but susceptibility to powdery mildew. EMR796 released as Malling™ Ace in 2021.

Figure 8. Fruit of Malling™ Ace (EMR796)

Conclusions

During the period covered by this report 1674 crosses were performed, 135,035 seedlings were assessed and 1329 selections made. A total of 1203 new selections were assessed in preliminary trials at NIAB East Malling with 78 selections progressing to preliminary growers' trials. Of these, 12 progressed to large-scale trial and five new varieties have been released:

EM2157	released in 2019 as 'Malling™ Allure'
EM2464	released in 2021 as 'Malling™ Vitality'
EMR564	released in 2019 as 'Malling™ Champion'
EMR639	released in 2019 as 'Malling™ Supreme'
EMR796	released in 2021 as 'Malling™ Ace'

Technology Transfer

- An AHDB members fruit walk was held at the NIAB East Malling trial site in June of every year during the project, with the exception of 2014 (when the season was very early and condensed), 2020 and 2021 (due to Covid 19 restrictions, although a virtual tour was made available) and 2022 when AHDB was winding down. These fruit walks allowed AHDB members to sample both new and advanced June-bearer selections from the EMSBC programme. Members were also given the opportunity to discuss the programme with Adam Whitehouse (Senior Breeder and Project Manager), Abi Johnson (Senior Breeder and Growers' Trial Co-ordinator) and Katie Hopson (Breeder) at these walks, and they were generally very well-attended with excellent feedback received from attendees.
- A recording for the BBC Radio 4 'Farming Today' programme was also made at AHDB Members Fruit Walk in 2016, and included interviews with both the strawberry breeding team and key growers (broadcast on 5 July 2016)
- AHDB elected or nominated representatives also attended and participated in the EMSBC Board Members' Fruit Walks and Board meetings in January/February, August and October each year (2013-22)
- Details of EMSBC programme and advanced selections were presented at four HDC/EMRA/NIAB EMR Soft Fruit Days at East Malling in November 2013, 2015, 2017, 2018, 2020, 2021 and 2022, and at the SSCR Soft Fruit Information Day, Inchture, Perthshire in February 2016
- Two presentations relating the EMSBC strawberry breeding programme were presented at the VII & VIII International Strawberry Symposia, Beijing in 2016 (Quebec, Canada) and (Rimini, Italy – virtual format) in 2016 and 2021 respectively.
- Presentations and posters detailing the EMSBC programme, varieties and advanced selections were presented at the BerryGardens Growers Ltd Technical Conferences in November 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020 (virtual), 2021 and 2022.

References

Whitehouse, A.B., Johnson, A.W., Cockerton, H.M, Nellist, C.F., Li, B., Wilson, F.M., Hopson, K.J., Passey, A.J., & Harrison, R.J. (2021) Recent progress in strawberry breeding and genetics at NIAB EMR, East Malling, UK (2021). Acta Hort. DOI:10.17660/ActaHortic.2021.1309.25

Whitehouse, A.B., Johnson, A.W., Hopson, K.J., Passey, A.J. & Sargent, D.J. (2021) 'Malling™ Allure' and 'Malling™ Champion': two new strawberry cultivars from NIAB EMR, United Kingdom. Acta Hort. DOI:10.17660/ActaHortic.2021.1309.24

Whitehouse, A.B., Simpson, D.W., Johnson, A.W., McLeary, K.J., Passey, A.J. & Troop, S.W. (2017) 'Malling Centenary', a short-day strawberry cultivar from NIAB EMR. Acta Hort. DOI:10.17660/ActaHortic.2017.1156.27

Whitehouse, A.B., Simpson, D.W., Johnson, A.W., McLeary, K.J., Passey, A.J., Nellist, C.F., Bates, H. & Harrison, R.J. (2017) Progress in strawberry breeding at NIAB EMR, East Malling, UK. Acta Hort. DOI:10.17660/ActaHortic.2017.1156.9

Whitehouse, A.. East Malling Strawberry Breeding Club. HDC Project SF 96a, Annual Reports, 2013-22

Appendix I

Scoring system employed for fruit and plant characteristics

Fruit characteristics:

Appearance	3=poor
	5=acceptable
	7=attractive
Skin Firmness	3=weak
	5=acceptable
	7=tough
Flesh Firmness	3=soft
	5=acceptable
	7=firm
Flavour	1=unpleasant
	3=poor
	5=acceptable
	7=pleasant
	9=very pleasant

Shelf life:

Overall Score	1=Very unattractive
	3=Unattractive
	5=Shape or colour may be uneven, there may be a few bruises
	7=Even shape and colour
	9=Attractive, looks fresh

Plant characteristics:

Plant Vigour	1=weak
	5=intermediate
	9=excessive
Plant Density	1=open
	3=intermediate
	5=dense
Fruit Display	1=poor
	2=intermediate
	3=good