A summary report for UK strawberry growers

7th North American Strawberry Symposium (NASS)
35th Annual Meeting of the North American Strawberry Growers Association (NASGA)

Tampa, Florida, USA
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Background

The HDC commissions applied research and development projects on behalf of their members but also provides information on new developments and best practice from around the world. David Simpson, from East Malling Research, attended the 7th North American Strawberry Symposium and HDC commissioned him to produce this report. It includes a summary of the information that is considered to be most relevant to the UK strawberry industry.

Introduction

The North American Strawberry Symposium (NASS) is held every 4 or 5 years and is always concurrent with an annual meeting of the North American Strawberry Growers Association (NASGA). On this occasion the 7th NASS and 35th NASGA meeting were held in Tampa, Florida from February 8th to 11th, 2011. Most of the presentations were made by scientists or extension specialists from USA or Canada but there were also several invited international speakers. The final day of the conference comprised a visit to three commercial farms and the University of Florida Strawberry Research Facility at the Gulf Coast Research and Education Centre.
This report focuses on the oral and poster presentations that were most relevant to UK growers and is organised by subject.

Attendance

The conference had approximately 350 delegates. Around 80% were grower members of NASGA, i.e. people with a practical involvement in strawberry production, propagation or direct marketing in Canada or the USA. The remaining 20% were mainly researchers, advisors, extension specialists and technical staff from marketing companies. The number of attendees from outside North America was relatively small, around 15-20.

Key topics

The conference included sessions on the following topics:

- Disease and Pest Management
- Breeding, Genetics and Genomics
- Production

Disease management

Charcoal rot (*Macrophomina phaseolina*)

This is a disease that we don't currently have in the UK but since the withdrawal of methyl bromide it has become one of the most important soil-borne diseases of strawberry in California, Florida, Mediterranean countries, North Africa and Australia. There were three presentations on *M. phaseolina* at the conference, from scientists in Australia, California and Israel.

Stanley Freeman (ARO, Volcani Research Centre, Israel) described the epidemiology of the disease, which causes symptoms similar to *Phytophthora cactorum*, i.e. wilting of the leaves followed by rotting of the crown and roots. The name 'charcoal rot' refers to the deep black colour of the mycelium. The disease has a wide range of alternative hosts and Freeman's team investigated isolates from five other plant species but found them all to be pathogenic on strawberry. High temperatures favour the disease and plants inoculated at 30^{o}C resulted in 100% plant death within two weeks. Symptoms developed much more slowly at 25^{o}C but plant mortality still reached 60% after 55 days. Sclerotia were found to remain viable for up to 44 weeks in the soil but this was also affected by temperature, with a more rapid decline in viability at 25^{o}C than at 30^{o}C. Chloropicrin was found to be very effective at

eradicating sclerotia from the soil but if infected crowns were present then the fumigant was only partially effective.

Don Hutton, a government scientist from Australia, reported problems with *M. phaseolina* in Queensland, where losses of 50-70% occurred with the cultivar Festival in 2009. The problem was thought to have been exacerbated by growing in rotation with sorghum, which is an alternative host for the disease.

Kirk Larson, from UC Davis, reported increasing losses from *M. phaseolina* in southern California. He explained that the disease is favoured by warm dry soils and has become a problem since growers have switched from methyl bromide to alternative fumigants, which are less effective. Screening of varieties had identified partial resistance in Seascape, whereas Diamante was found to be very susceptible.

Currently the weather conditions in the UK do not appear to favour *M. phaseolina* but this situation could alter due to climate change. Also, as has been observed with black spot (*Colletotrichum acutatum*), diseases can evolve new strains that are adapted at lower temperatures. For these reasons it will be important to keep *M. phaseolina* out of the UK by being vigilant and taking care not to import any infected plant material.

Angular leaf spot (*Xanthomonas fragariae*)

This bacterial disease was rife in Florida and infected plants were widespread on all the commercial farms visited. From discussions with growers and advisors it was clear that the disease was being introduced on nursery plants but was then spreading rapidly in the fields. Weather conditions in Florida during the winter of 2010/11 had been very conducive to the disease, with much higher than average rainfall.

Bill Turechek from USDA Agricultural Research Service, Florida, gave a presentation. He had used *Xanthomonas* labelled with green fluorescent protein (GFP) to study the epidemiology and proved that the bacterium lives systemically in the plant vascular system. He had concluded that the primary source of infection to fruiting fields was on symptomless systemically infected plants from the nurseries. The pathogen can survive epiphytically on plant tissue but does not survive in the soil, so can be eliminated between crops by good hygiene and husbandry methods.

Turechek reported on work where he and **Natalia Peres** had investigated different methods for controlling the pathogen on nursery plants. Heat can destroy the bacterium and 15 minutes in water at 56^{o}C was very effective but this was too hot for the plants and most died. Two hours at 48^{o}C or 4 hours at 44^{o}C gave quite good control but also resulted in some plant deaths. Bagged plants survived much better than plants dipped directly in the hot water. Radio frequency wave treatments was an alternative way of delivering heat but this is expensive. Surface sterilizing using bleach or UV-C radiation were also tried, along with trimming leaves from the nursery plants. All of these had a positive effect in reducing the amount of the pathogen. Overall, no one method was found to eliminate *X. fragariae* from planting stock. However, a combination of heat, bleach dip and trimming leaves significantly reduced the amount of bacterium introduced into the fruiting field and achieved good disease control.

There are four strains of *X. fragariae* that can be identified by molecular methods (PCR) or using alternate hosts. Some cultivars are resistant to individual strains but none is resistant to all four. However, **Andrew Jamieson** from Agriculture and Agri-Food Canada, Kentville, Nova Scotia, reported on breeding to introduce resistance from the wild species *Fragaria virginiana*. He has completed three generations of back crossing so far and expects to identify some resistant lines with cultivar potential after one or two more generations.

Powdery mildew (*Podosphaera aphanis*)

This disease is a problem for strawberry growers worldwide, particularly when cropped under polytunnels. **David Gadoury** from Cornell University, New York State, had looked at pathogen survival over winter and found no evidence of survival in crown tissue. However, the pathogen did survive as cleistothecia on senescent persistent leaves and these often provide an abundant source of inoculum to initiate early epidemics in the growing season. Cleistothecia are very persistent and do not get dispersed by wind or rain. In an interesting field experiment, Gadoury found that a planting established using disease-free plants remained free from powdery mildew for one season, despite high disease pressure from adjacent plantings. However, the disease developed strongly in the second year.

Gadoury also explained about ontogenic resistance, which is the process by which leaves become more resistant as they age. Only very young leaves are susceptible to infection and this results in more disease on the lower leaf surface, as the leaf is folded when infection first occurs. By the time the upper leaf surface is exposed to mildew spores it has aged substantially and is quite resistant to infection. The same process of ontogenic resistance also occurs rapidly on fruit, with only young green and white berries susceptible. All this information is being incorporated into revised control strategies for powdery mildew and the suggestion is that early intervention and suppression of the disease is extremely important.

Anthracnose (*Colletotrichum* spp.)

Barbara Smith, from USDA, Poplarville, Mississippi has researched strawberry anthracnose diseases for over 20 years and she presented an overview of the current situation in the USA. Three species are responsible for disease problems: *Colletotrichum acutatum* is familiar to UK growers as the cause of black spot, while *C. fragariae* and *C. gleosporiodes* are currently absent from UK strawberry farms but cause serious crown rot problems in south-eastern USA. *C. acutatum* is mainly splash dispersed and has become

less of a problem in the UK since the widespread adoption of polytunnels. However, the disease is still a major problem in the USA and Smith explained that it can take as little as two days from fruit infection to spore production if conditions are favourable. The pathogen can survive for 11 months in the soil in warm dry conditions (e.g. California) and spores remain viable for five weeks on clothing. Where tunnels are not used it is important to minimise rain splash and sowing a living mulch, e.g. ryegrass, between the beds will reduces splashing. The grass is allowed to grow to produce a good cover and is then killed with herbicide. Until relatively recently *C. acutatum* was considered to be a warm weather pathogen (optimum 26-28^{o}C) but it has become adapted to cooler temperatures in North America, as it has in Europe. It is now occurring in nurseries in northern California, northern USA and Canada. Hot water dipping treatments can be effective to eliminate *C. acutatum* from transplants but this has not been widely adopted as it affects plant vigour. The best fungicide treatments have been found to be Switch (Syngenta) and Pristine (BASF).

Strawberry viruses

Ioannis Tzanetakis, from the University of Arkansas, gave an overview of strawberry virus problems. There are increasing numbers of viruses attacking strawberries as the crop is planted in new regions, resulting in exposure to different viruses. In the UK we are familiar with four aphid-transmitted viruses – *Crinkle, Mottle, Mild yellow edge* and *Vein banding* – and *Chlorotic fleck* has now been added to this list. There are now also five 'new' viruses that are transmitted by whitefly, which have been found in California and north eastern USA. The whitefly need to feed for 6 hours to acquire the virus from an infected plant and 12 hours feeding is required for transmission. *Strawberry necrotic shock* virus is also a problem in the USA. This belongs to the ilarvirus category, for which the vectors are unknown but transmission often occurs through pollen transfer. Molecular research is being undertaken in the USA to develop a microarray capable of detecting all known viruses of strawberry. It

is anticipated that fungal and bacterial pathogens will be added at a later date, thus providing a ‘one-stop shop’ for verifying high-health stocks.

Disease forecasting systems

Natalia Perez, from the University of Florida, described a web-based decision support tool known as the Strawberry Advisory System (SAS). This is available on http://agroclimate.org/tools/strawberry/ and provides growers with recommendations for timing fungicide applications to control Anthracnose and Botrytis fruit rots. Growers go online, select the location closest to their plantings and SAS then provides a prediction of disease risk and recommendations for applying fungicide sprays. Users can also opt to receive warnings of the need to spray by text messages to their mobile phones. This service is clearly popular with growers as it is user friendly and helps to eliminate unnecessary fungicide sprays.

Perez had compared three disease forecasting models for their effectiveness on timing of fungicide applications. She found that the best models reduced the number of sprays by 50% for Botrytis and 38% for anthracnose (compared to spraying by the calendar) with no reduction in disease control or yield. The key model parameters were found to be timing and length of leaf wetness period and the temperature during wetness.

Pest management

Spotted wing drosophila (*Drosophila suzukii*)

James Price, from the University of Florida, presented a poster on the occurrence of spotted wing drosophila (SWD) in Florida. The pest was originally restricted to Asian countries but was detected in Watsonville, California in autumn 2008. Lure-trapping was instigated in Florida and the first adults were found in summer 2009, close to a fruit market that was selling cherries from western USA. Subsequently SWD was found to be spreading

through Florida but was checked by an unusually cold winter in 2010. No commercially damaging larval infestations were found in strawberries in 2010 but it has been concluded that this will become a permanent pest on Florida strawberries, which can't be ignored. Growers are being told to remove all berries from the field when harvesting, not leaving any waste in the alleys. Researchers in Florida believe that SWD will become a much more serious pest of cherries and raspberries than it will of strawberries.

Sap beetles (*Lobiopa insularis* and *Haptoncus lutelous*)

These beetles enter Florida fields in late winter, chew holes in ripe fruit and then reproduce there. Relatively small numbers of sap beetle adults can inflict serious damage on crops and the most effective insecticide (methomyl) was withdrawn in 2007. **James Price**, University of Florida, has been investigating the efficacy of alternative pesticides over four years. He found that the growth regulator novaluron is an effective control agent for larval stages while bifenthrin and acetamiprid provided the best control of adult beetles.

Genetics and breeding

Resistance to Verticillium wilt (*Verticillium dahliae*)

Agnieszka Masny from the Horticulture Research Institute at Skierniewice, Poland, has been studying resistance to *Verticillium dahliae* and described field experiments over three seasons where she had assessed the resistance of 93 cultivars. The most resistant were Senga Sengana and Salsa, along with five Polish cultivars: Aga, Dukat, Fara, Salut and Vikat. Among the more widely grown cultivars, Chandler, Elianny and Charlotte showed useful levels of resistance. Masny conducted a genetic experiment where 10 cultivars were crossed in all combinations and the progenies assessed for susceptibility over two seasons. She concluded that the cultivars Selvik and Filon were the best parents for passing on resistance but Sonata also performed well.

Herbicide resistance

Resistance to the herbicide glyphosate is normally associated with GM technology but **Adam Dale**, at Simcoe Research Station, Ontario, Canada, has been investigating naturally occurring resistance in strawberries. He began by screening potted plants from a random seedling population of 59 families. Plants were sprayed with 1% glyphosate and the more resistant individuals were mostly found to be related to clones of the wild species *Fragaria virginiana*. In a second experiment 2500 seedlings were sprayed in the field with 2% glyphosate at the end of the season, with 56 surviving to the following spring. Following further trials and some crossing and selection, Dale now has four selections that show 85% survival after spraying with 2% glyphosate. He has also screened 50 accessions of *F. virginiana* and found two, Eagle 10 and Eagle 14, that show good resistance. Further breeding offers the prospect of glyphosate-resistant cultivars in future but this could take several generations and many years to achieve, as integrating traits from a wild species is a slow process.

Strawberry breeding in Florida

Vance Whitaker has recently taken over from Craig Chandler as the head breeder at the University of Florida. Breeding began there is 1948 and Whitaker recently completed a trial comparing fruit quality traits for a range of varieties that had been released from the programme over the years. The average berry size has been increased from 15g to 30g, with a parallel increase in the percentage of Class 1 fruit and greater uniformity of shape. In contrast the ratio of sugar to acids has shown no trend with time but Elyana (2008) has a very high ratio of sugar to acid. It was found that the sugar:acid ratio correlated well with sensory sweetness ratings and a correlation was also found between sugars and some aroma volatiles. Currently the most successful cultivar from the programme is Festival, which accounts for 50% of the Florida acreage. It was notable that Festival exhibited no extreme values

for any of the fruit quality traits measured in the trial, demonstrating the importance of combining multiple fruit quality traits to achieve success in the market.

Rain damage

Mark Herrington breeds strawberries in Queensland, Australia, where most strawberries are grown in the open field. Rain damage is a common problem and he had noted differences between the cultivars in commercial production. The most common form of damage is ‘etch’, where there is tissue degeneration and the seeds become more pronounced, resulting in a soggy patch either at the tip or on the body of the berry. Following a period of rain, three cultivars were evaluated and Rubygem had 80% of fruit damaged whereas Festival (55%) and Camarosa (61%) were affected less. Herrington is attempting to breed for improved rain tolerance and has developed an assay where slightly immature berries are soaked for 2-3 hours in deionised water. Results from this assay have given a very strong correlation with field data.

Production and cultivation

Lighting treatments

Tom van Delm, from Hoogstraten Research Centre, Meerle, Belgium, presented results from glasshouse experiments where the everbearing variety Charlotte was grown under different lighting regimes. A+ runners were planted in substrate in early February and given additional lighting during the nights, 15 minutes per hour from February 20th to March 31st. The lighting treatment resulted in 50% fewer runners and a yield increase of 1kg per m^2, compared to the unlit controls. The percentages of large and Class 1 berries also increased significantly in the plants with additional lightling. The increased yield was all concentrated in the early part of the season, from mid May to the end of June. In a second trial, the cultivar Portola was planted five weeks

later, on March 11th. The plants were given different light and heat treatments for 50 days in a glasshouse before being placed outside on table-tops.In this case the lighting treatment again reduced runnering and advanced the season of production but there was no effect on total yield.

Irrigation and nutrition research in Florida

Bielinski Santos, from the University of Florida, has been investigating methods of reducing water and nitrogen use in strawberry production, as forthcoming changes in regulations will force growers to change their practices. Water is used for plant establishment, maintenance irrigation and frost protection, with 950-1400mm per acre per season applied in total. Santos has been comparing methods for reducing water use in all three areas. For establishment the use of kaolin clay to reduce transpiration has reduced the requirement for sprinkler irrigation from 10 days to 6 days, with the kaolin applied on the 7th day. For maintenance irrigation Santos found that reducing the volume by 50% in the early part of the season had no effect on growth or early yield. However for the second half of the season it was not possible to reduce irrigation significantly without affecting the total yield. For frost protection the treatments compared included mini sprinklers, row covers (fleece), foam and high tunnels. By far the most effective was the use of high tunnels, which increased early and total yields by 28% and 55% respectively, with no additional frost protection needed. Previously high tunnels have been considered too expensive by most Florida growers but there were 13 serious frosts in early 2010, compared to an average of 4 to 5. This, combined with the yield benefits, is making the capital investment in tunnels look more attractive and Santos expects their use to increase dramatically in the next few years.

The soils in Florida are 95-98% sand and regulations are being introduced to control nitrogen use and reduce leaching. Santos has been experimenting with different N rates and has found that the optimum ratio of N:K differs greatly with different cultivars. For example, the optimum N application for maximum yield in Winter Dawn was 25% less than for Festival. Interestingly,

growers now need to add sulphur to their fertilizer mix in Florida. Formerly this was unnecessary due to acid rain but this has reduced due to environmental pressure to reduce sulphur emissions.

Conclusions and recommendations for UK growers

Strawberries are produced in many states across USA and Canada, covering a wide range of environmental and climatic conditions. Information from the northern states is most relevant to UK growers today but the changing climate means that some pest and disease problems currently present in the southern states may soon arrive in Britain. The key points from the conference are listed below:

- Charcoal rot (*Macrophomina phaseolina)* is a soil-borne disease that has become a problem in hot climates since growers stopped using methyl bromide. To avoid future problems, it is important not to import infected plant material into the UK.

- Angular leaf spot (*Xanthomonas fragariae*) is not yet a problem in the UK but may arrive in the future. It can survive epiphytically on plant tissue but does not survive in the soil, so can be eliminated from fields between crops by good hygiene and husbandry methods.

- Production of disease-free nursery plants is the best way to control the spread of *X. fragariae*. A combination of heat, bleach dip and trimming leaves was found to significantly reduce the amount of the bacterium on runner plants.

- Black spot (*Colletotrichum acutatum*) is still a major problem for open field strawberry production. It can take only two days from fruit infection to spore production in favourable conditions. The pathogen can survive for 11 months in the soil and spores remain viable for five weeks on clothing.

The best fungicide treatments in the USA are Switch (Syngenta) and Pristine (BASF).

- Problems with powdery mildew (*Podosphaera aphanis*) are frequently caused by the disease overwintering on senescent persistent leaves. To achieve effective control it is extremely important to achieve early intervention and suppression of the disease at the beginning of the season.

- The cultivars Elianny and Charlotte show useful levels of resistance to wilt (*Verticillium dahliae*).

- The web-based Strawberry Advisory System (SAS) provides Florida growers with recommendations for timing of fungicide applications. UK growers can see how the system works by visiting http://agroclimate.org/tools/strawberry.

- Spotted wing drosophila arrived in Florida in 2009 and it has been concluded that it will become a permanent pest on Florida strawberries, which can't be ignored. Growers are advised to remove all berries from the field when harvesting, not leaving any waste in the alleys.

- Providing additional lighting in February and March for glasshouse-grown everbearers results in fewer runners and higher yield per m^2. The increased yield occurs in the early part of the season, from May to June.

- The use of kaolin clay to reduce transpiration can reduce the need for sprinkler irrigation when establishing cold-stored runners in warm, dry conditions.

