AHDB HORTICULTURE

Grower Summary

SF 137

Timing of nitrogen applications to optimise growth and yield without adversely affecting fruit storability and frost sensitivity

Final 2015

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GROWER SUMMARY

Headlines 2015

- The use of a low nitrogen regime in pot grown Duke blueberry not only reduced fertiliser costs but also reduced picking costs as a result of larger fruit.
- There were no adverse effects on plant growth or cropping for high nitrogen regimes and nitrogen was not a limiting factor at the lowest regimes.

Background and expected deliverables

This project aimed to ascertain the effects of different nitrogen application regimes on growth, yield, storage and frost sensitivity of two blueberry varieties – Duke and Aurora - to address gaps in knowledge about the timing of and optimum feed regimes.

The intended deliverable was to identify an adequate level of nitrogen feed for blueberry in pot grown systems. It was hoped that potential benefits of varying nitrogen through the season would be seen. Benefits from further work may include assessing adequate levels for other nutrients including potassium, phosphate and magnesium.

Optimum growth of canes is required to maximise the yield of blueberry bushes, with larger bushes having greater potential yields. Although nitrogen application is important for encouraging growth, it is not without potential problems. During fruiting, high nitrogen application has been shown to reduce fruit firmness in a number of crops and may reduce storage life. Commercial experience has shown that damage to developing flowers caused by frosts during autumn and winter can have adverse impacts on yield, with late nitrogen applications believed to increase sensitivity to frost. Excessive nitrogen applications at the time of autumn flower initiation also have the potential to reduce flower number. Anecdotal evidence from other blueberry growing areas suggests that nitrogen applications post-harvest can lead to late season bud break with the production of new shoots in the autumn, thereby reducing yield, since potential fruit buds are 'lost' to vegetative growth. Moreover, this late growth is said to be highly susceptible to damage by late autumn or early winter frosts. On the other hand, inadequate nutrition during flower initiation in the autumn has been shown to reduce crop potential in Southern Highbush blueberries. Each of these effects may have a considerable influence on yield.

The blueberry crop is relatively new to the UK with growers largely adopting pot grown production systems. Elsewhere in the world blueberries are predominantly soil grown.

Consequently the majority of research into blueberry nutrition requirements has generally been conducted on field grown crops, so there is a need for trials to determine the optimum feeding regime in pot grown blueberries. It was hoped the work would lead to a number of commercial benefits:

- Pot grown plants are more sensitive to changes in the nutrients applied through the irrigation system and so this presents growers with an opportunity to manipulate nutrient balance to improve production.

- An understanding of the role of nitrogen at specific times of the year would allow the targeting of nitrogen applications where they would have most benefit.

- Determining how or whether nitrogen can be applied in the run up to fruiting without reducing storage potential could extend the market for UK blueberries.

- Yield losses due to frost damage are not sustainable and so a method of reducing the risk of frost damage is needed.

The two main objectives of the work are:

- **Objective 1:** Test the effect of three constant nitrogen levels on growth and yield (March 2012 - October 2012)
- **Objective 2:** Examine the effect of increasing and decreasing nitrogen feed levels during three key phases of growth: early spring growth, fruiting and autumn flower initiation (October 2012 - October 2015)

Summary of the project and main conclusions

The project was run at Brogdale Farm, Faversham, Kent. Three year old blueberry bushes of the varieties Duke and Aurora were sourced from Hall Hunter Partnership (HHP) in 25L pots on 6 March 2012. The variety Duke was sourced from Heathlands Farm, Wokingham and the Aurora was sourced from Tuesley Farm, Milford. The plants were selected for uniformity using a standard system. For Duke, the plants required three to five main structural branches and for Aurora, plants with two or three main structural branches were selected.

On arrival at Brogdale, the pots of the variety Duke were placed on a black Mypex floor covering, in a Spanish Tunnel. The tunnel was covered from bud break until the end of cropping at which point the plastic cladding was removed. The Aurora pots were placed outside on a black Mypex floor covering in line with commercial practice.

Objective 1: Test the effect of three constant nitrogen levels on growth and yield (March 2012 - October 2012)

Three feed solutions were supplied to plants with 60ppm N, 120ppm N or 180ppm N from March to October 2012. Ninety plants of each variety were arranged in a randomised block design with six plots per treatment. Irrigation was supplied to achieve a target of 60% substrate moisture content whilst maintaining EC within set limits. The nitrogen applied was in the form of 70% ammonium nitrogen and 30% nitrate nitrogen.

Shoot lengths of tagged and labelled shoots were recorded monthly from March to October 2012 to determine whether the nitrogen treatments stimulated different levels of growth. In addition, fruit were harvested weekly and the number and the weight of fruit were recorded for each plot. Fruit brix° was recorded from 20 fruit per plot twice during the cropping period of each variety along with shelf life.

The results of the work in Objective 1 have been summarised in previous annual reports.

Objective 2: Examine the effect of increasing and decreasing nitrogen feed levels during three key phases of growth: early spring growth, fruiting and autumn flower initiation (October 2012 - October 2015)

A separate batch of 252 plants of each variety is being used for the nitrogen timing treatments. These were sourced from HHP in March as above and were grown on at Brogdale for four months at 120ppm N from April 2012 to August 2012. At this point, on 15 August, the first treatment applications started with the application of the autumn treatments until 15 October 2012 (autumn high and autumn low below). Timings are based on specific growth stages although approximate timings are shown below for reference.

The plants were arranged in a randomized block design with six plots per treatment and seven plants per plot. Three separate lines of irrigation for the three nitrogen treatments allowed the plants to be plugged into the correct nitrogen treatment at the three points during the season outlined below (all dates vary according to the season).

'Autumn High'. A nitrogen level of 180mg/L was applied from the end of harvest until 90% leaf fall (15 August to 15 October 2012) and then 120mg/L was applied from bud break until the end of harvest (17 April to 12 September 2013).

'Autumn Low'. A nitrogen level of 60mg/L was applied from the end of harvest until 90% leaf fall (15 August to 15 October 2012) and then 120mg/L was applied from bud break until the end of harvest (17 April to 12 September 2013).

'Spring High'. A nitrogen level of 120mg/L was applied from 15 August to 15 October 2012. 180mg/L was then applied from bud break until first green fruit (17 April to 1 July 2013) and then decreased again to 120 mg/L until 12 September 2013.

'Spring Low'. A nitrogen level of 120mg/L was applied from 15 August to 15 October 2012. 60mg/L was then applied from bud break until first green fruit (17 April to 1 July 2013) and then increased again to 120mg/L until 12 September 2013.

'Summer High'. A nitrogen level of 120mg/L was applied from 15 August to 15 October 2012 and from bud break until first green fruit (17 April to 1 July 2013). This was then increased to 180mg/L from first green fruit until the end of harvest (1 July to 12 September 2013).

'Summer Low'. A nitrogen level of 120mg/L was applied from 15 August to 15 October 2012 and from bud break until first green fruit (17 April to 1 July 2013). This was then reduced to 60mg/L from first green fruit to the end of harvest (1 July to 12 September 2013).

'Medium'. A standard nitrogen concentration of 120mg/L was applied from 15 August to 15 October 2012 and then from bud break until end of harvest (17 April to 12 September 2013).

'Low'. A nitrogen concentration of 60mg/L was applied from 15 August to 15 October 2012 and then from bud break until end of harvest (17 April to 12 September 2013).

'High'. A nitrogen concentration of 180mg/L was applied from 15 August to 15 October 2012 and then from bud break until end of harvest (17 April to 12 September 2013).

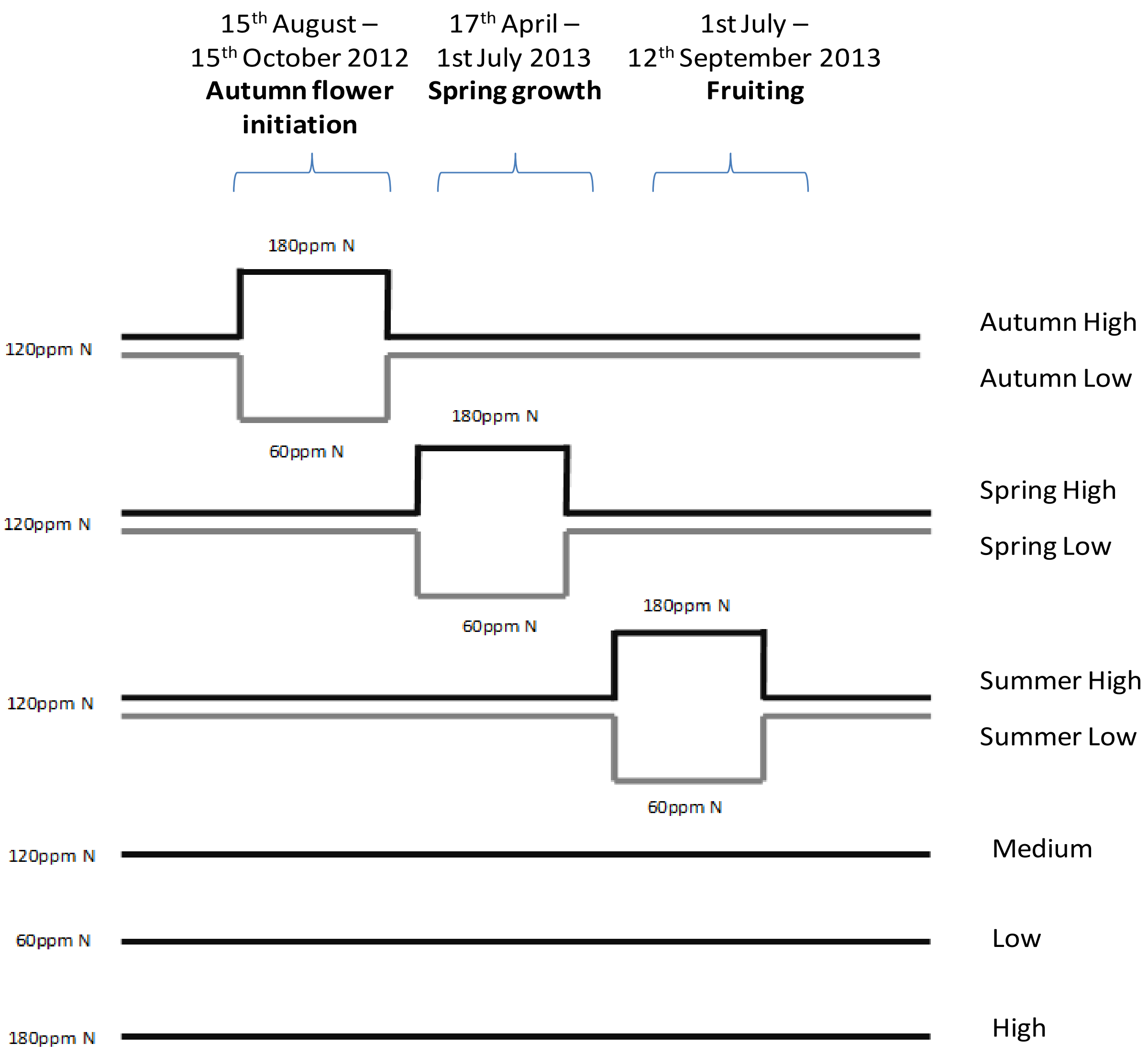

Figure 1. The treatments which were applied in Objective 2 of the project

From each treatment the growth, cropping and plant nutrition were assessed. These assessments began in 2013 apart from the growth measurements from the autumn high and autumn low treatments, which began in autumn 2012.

The assessments which were made included:

Growth	Shoot growth measured from labelled branches at the end of each of the three nitrogen application timings at the following timings – green fruit, end of cropping and 90% leaf fall.

Cropping	Fruit was harvested, counted and weighed, separated into Class I, Class II and Waste fruit to determine the effect of treatment on yield and overall fruit quality.
Storability	Both the Aurora and the Duke were placed into an air store at 2°C at Brogdale and assessed fortnightly until deemed non-marketable. The Duke was also placed into a CA store at Hall Hunter Partnership on 1 August and assessed after four and eight weeks. Assessments made fortnightly were as follows: • Percentage fruit with shrivel • Weight loss during storage • Fruit collapse • Flavour • Overall marketability based on commercial specifications supplied by HHP
Flower initiation	The percentage of floral buds was calculated and the average number of flowers per bud was recorded.
Percentage bud break	The percentage of buds which broke from each treatment was assessed.
Plant nutrition	Leaf samples were taken and analysed for nutrient content on 11 July and 4 September. In addition, irrigation input and runoff was analysed on 16 July.

The results from Objective 2 from 2012-2014 are summarised in previous reports.

Objective 2 results from 2015

Autumn 2014 was the third year during which nitrogen levels were increased and decreased depending on growth stage, namely: early spring growth, fruiting and autumn flower initiation. There were six different changing nitrogen regimes and three constant nitrogen reference regimes. The base nitrogen level applied was 120 mg/L and referred to as the 'Medium' feed and the treatments were either increased to 180 mg/L ('High') or decreased to 60 mg/L ('Low) at one of the three phases mentioned.

There were very few statistically significant results in 2015. However, in this trial overall, Aurora had higher percentage bud break than Duke – around 85% compared to 70%. Aurora also had approximately 55% floral buds compared to Duke at 40%. This is reflected in the total yields which in 2015 increased for Aurora (per pot average of 1.8kg compared to 1.6kg in 2014) but were static for Duke at an average of 2.3kg. The plants have not yet reached their maximum yield potential.

Percentage Class 1 (C1) fruit was higher for Duke than Aurora (92% compared to 88%). This was due to increased waste fruit for Aurora compared to Duke. Low nitrogen treatment for both varieties yielded the greatest C1 fruit per bush but results were not significant and differences between treatments were only 4%. Aurora Low had significantly lower Class 2 (C2) fruit than most other treatments but also the highest waste.

Low nitrogen treatment advanced ripening for both varieties during 2015 although marginally. However, in 2014, Low N retarded ripening.

Aurora had slightly heavier berries than Duke – 1.6g average compared to 1.5g, but Duke Low fruit were significantly heavier (1.7g) than any other treatment.

Berry size differences within varieties were minimal and not significant but Duke berries were slightly larger with an average of 14.6mm whereas Aurora were 13.7mm. The largest berries for Duke were from the Low treatment.

Low nitrogen treatment decreased Brix^0 in Duke but increased it in Aurora. Duke fruit had higher Brix^0 on average than Aurora– 12.8 compared to 10. Aurora Summer High had the lowest Brix^0 and, as in 2014, Autumn Low the highest (10.7). Values for Duke were highest for Medium nitrogen treatment and Low, Summer Low and Autumn Low had significantly lower Brix^0 than other treatments, which was similar to 2014, but all values were higher than for Aurora.

There were no significant impacts on cold storage for either variety. However, Aurora had a much greater percentage of marketable fruit remaining after the 8 week period concluded - >50% compared to <10% for Duke. Aurora Medium treatment performed best and losses were mainly due to dehydration and *Botrytis*. Greatest losses for Duke were from collapse and *Botrytis*. Duke Autumn Low performed best but marginally.

Shoot lengths appeared unaffected by treatment in 2015 for both varieties. Aurora shoot lengths for all treatments were very similar but High nitrogen reduced shoot growth compared to all other treatments, although not significantly. Applying Low nitrogen in Duke increased shoot length significantly however, but it is not known whether this is a seasonal effect, as seen in 2014.

Winter 2014/2015 and spring 2015 were again unusually mild in the south east of England. There were no harsh frost events, which prevented conclusions from being drawn on the impact of nitrogen nutrition on frost hardiness.

Main conclusions drawn from the first three years (2012-1014)

Low rates of nitrogen reduced growth rates in Duke during the first two years of the trial but had no effect in 2014. This effect on growth did not have any apparent impact on yield.

Variety Aurora showed no response in terms of improved growth or yield to increasing levels of nitrogen.

Low N reduced storage losses in 2013 and 2014.

Increasing nitrogen levels to 180mg/L during the summer gave higher Brix (º) in Duke berries in years 2013 and 2014.

Main conclusions drawn from the final year (2015)

As stated previously, there would seem to be little benefit in using higher levels of nitrogen throughout the season, though increasing N in the summer could improve Brix (º) levels in Duke. Lower nitrogen rates would lead to reductions in fertiliser costs and have less environmental impact.

Benefits were seen from the Low N treatment in Duke (fruit weight) which is similar to results obtained in 2013 and 2014. Changes to feed regimes should be accompanied by careful monitoring of N levels in the run off.

There were no benefits for Aurora from increased levels of N.

Main conclusions from the life of the project (*2012-2015*)

In general there was little effect from varying N levels throughout the season or for periods within the season. There were no adverse effects on plant growth or yield at the highest N concentration of 180mg/L and it would appear that N levels of 60mg/L would be adequate for blueberries since N is not a limiting factor at this low regime. However, there were indications that there was also some consistency in maintenance of improved Brix^0, % marketable fruit out of store and Class 1 yields over the seasons for the following regimes:

- Aurora: Autumn Low / Spring High

- Duke: Autumn Low

Table 10 in the Science Section of the report summarises the treatment effects of all assessments.

Financial benefits

The most likely sources of financial benefits to growers are:

- Potential saving of £270 per ha when using a low N regime (60mg/L) compared to a High N regime (when N = £1.50kg, approximately) (Duke and Aurora)
- Potential savings of 30p to 40p / kg on picking costs (when costs are around £1.50 to £2.00 per kg to pick) (Duke - assuming Low N results in 20% heavier fruit as seen in this trial)

Action points for growers

- Nitrogen feed concentrations of 60mg/L appear to be adequate for pot grown commercial blueberries.
- To achieve improved Brix°, marketable fruit out of store and class 1 yields, use the following nitrogen feeding regimes: Aurora – Autumn Low / Spring High, Duke: Autumn Low