A review of the effects of bark applied nutrient sprays used on blackcurrants in 2020

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Background

The large majority of the blackcurrant cultivars that are currently used by commercial growers have been bred at the James Hutton Institute in Dundee and many of these have been bred using germplasm from Scandinavian cultivars which offer additional cold hardiness for northern European climates. Climate change has resulted in mild wet winters for many UK growers and in many seasons, such weather patterns offer insufficient chilling to ensure that buds on blackcurrant bushes break evenly, and in some cases, buds don't break at all. This not only results in reduced yield potential, but also uneven bud, flower and fruit development, which does not lend itself to a single pass with a blackcurrant harvester, whilst leading to more under-ripe fruit being picked and lower marketable yields.

To address this problem, an IUK funded project led by NIAB EMR and the James Hutton Institute with blackcurrant industry support, developed models of chilling requirements in some commercial blackcurrant varieties and identified bark applied nutrient sprays which may induce budbreak, even in the absence of chilling. However, the work has not followed through to harvest to look at yield or quality. Lucozade Ribena Suntory Ltd (LRS) process a very large proportion of blackcurrants in the UK and routinely sample the crop for quality when processing. They also have access to management data including information on the application of nutrient sprays. During and since the conclusion of the IUK project, several growers have been trialling areas with and without bark applied nutrient sprays. Both the James Hutton Institute and LRS have access to weather information covering the areas in which the growers operate, often from sensors at the grower locations.

AHDB commissioned the James Hutton Institute to undertake this desk study in collaboration with Harriet Prosser (technical officer for LRS in the UK). Harriet provided fully anonymised application records, harvest dates, yield and fruit quality data for crops treated with different nutrient sprays in 2020 and these were compared to the equivalent data from areas of crops not treated with these sprays (controls). The study aimed to provide insight into the effect of these sprays used by blackcurrant growers across the UK in 2020, taking account of the location, variety planted and whether the chill requirements were met.

Summary of findings

There was insufficient data to examine the effect the on-farm trials had on yield and bush vigour so the study focussed on measures of quality. Exploration of the wider grower data set yielded, suggested that the effect of bark applied nutrient sprays seems to depend on varieties with Ben Lomond and Ben Gairn being most affected. Ben Gairn benefited from nutrient sprays showing an increase in BRIX score and a decrease in red berries, when chilling requirements were not met, preventing a significant drop off in quality scores. Ben Lomond showed a decrease in BRIX score and an increase in red berries when nutrient sprays were applied despite never achieving the required chill accumulation.

In general, there appears to be a decrease in BRIX and an increase in Red Berries where chill requirements were met and nutrient sprays were applied. However, this result needs to be treated with caution and would benefit from investigation in a more controlled environment and split-field trials.

Data collection

An anonymised data set was provided to JHI by LRS consisting of over 2000 fruit sample data points from 30 farms across the country supplying blackcurrants to LRS in 2020. Quality data is routinely collected by LRS on a subsample of 500g from of every tenth bin of fruit sent for processing. Alongside this management data submitted to LRS was incorporated which provided information on what, if any, bark applied nutrient sprays were used and, if applicable, the date of application. In addition, a subset of growers marked bins of fruit from equal areas of treated and untreated blackcurrant from which quality and yield data were to be collected. Unfortunately, due to the arrival time of several of these shipments, the processing teams were not able to separate the samples, so this data was not collected.

Hourly temperature data is available from Canterbury, Invergowrie, Newent and Teynham collected from on-farm monitoring and, in the case of Invergowrie, the local Met Office monitoring station. There is more geographically complete information on the total number of chill hours under 7°C between October 2019 and February 2020 with information for Perthshire, Kings Lynn, Coggeshall, Marden, Teynham, Faversham, Canterbury, Byford, Newent, Taunton, and Invergowrie. Chill models from the Innovate UK Project show a non-linear relationship between chilling accumulation and temperatures so require temporally resolved temperature data which is only available for four locations with none in Somerset, Essex, or Norfolk. They are calibrated to budbreak and therefore more closely linked to yield than quality so, in the absence of yield data, we use the simpler, but more geographically comprehensive chill hours data detailed in Table 1. Chill requirements (shown in Table 2) were taken from AHDB recommendations published on https://ahdb.org.uk/blackcurrant-chill-hours-model.

Table 1. The approximate number of hours below 7 C between 1 October 2019 and 29 February 2020

Location	Region	Chill Hours (<7°C)
Perthshire	Scotland	2,456
Kings Lynn	Norfolk	1,771
Coggeshall	Essex	1,610
Marden	Kent	1,425
Teynham	Kent	1,440
Faversham	Kent	1,524
Canterbury	Kent	1,371
Byford	West Midlands	1,882

Newent	West Midlands	1,526
Taunton	Somerset	1,356
Invergowrie	Scotland	2,326

Table 2. Chill requirements by blackcurrant variety

Variety	Required Chill Hours < 7°C
Ben Starav	1684
Ben Klibreck	2138 (c.1800 from field experience)
Ben Gairn	1424
Ben Alder	2157
Ben Tirran	2328
Ben Hope	1526
Ben Dorain	2014
Ben Vane	1400
Ben Lomond	2022
Ben Avon	2157
Ben Lawers	1500

Methods

The absence of data from the trial growers means that a more exploratory approach is necessary. There are relatively few samples of Ben Avon and no samples where a bark applied nutrient spray was not used so the variety has been dropped from the analysis. The chilling in each area and approximate chill requirements detailed in Table 1 andTable Table 2 were used to calculate whether the chill requirement for each sample was met. A linear mixed model approach was then used to explore the effect of whether the chilling requirement was met and dormancy release for the different blackcurrant variety. Specifically, random effects were used to account for variability between regions and growers. Fixed effects were fitted for application of dormancy release compounds, whether chill requirements were met, variety, and the interaction between them. Response variables of quality data for the samples were analysed, specifically BRIX score at 20°C, the weight of Red Fruit, Green Fruit, Shrivelled Fruit, Sun scorched Fruit and fruit with botrytis in a 500g sample, the weight of 100 randomly selected berries and the Quality Index (an LRS calculation bringing all the above parameters together into one percentage score). Log transformations were applied where appropriate and in cases with relatively few non-zero observations, presence-absence models were fitted using a binomial generalized linear mixed model with a logistic link. Significance was assessed using sequential Kenward-Rogers adjusted F-tests for linear mixed models and likelihood ratio tests for logistic presence/absence models and insignificant higher-level interactions were removed. All analysis was carried out in R 4.0.3 using packages lme4 and pbkrtest.

Results

BRIX score

Variety had the greatest explanatory power for BRIX score ($F_{9,1905.6} = 20.65$, $p < 2.2e\text{-}16$). The effect of bark applied nutrient sprays depended on the variety ($F_{9, 1898.8} = 6.79$, $p = 1.18e\text{-}09$). For most varieties there was either no discernible difference or insufficient evidence because of less precise estimate, but BRIX scores were higher with treatment for Ben Gairn and lower for Ben Lomond and Ben Starav (Figure 1). Bark applied nutrient sprays tend to increase BRIX scores if the chilling requirement had not been met but decrease them if they have been met ($F_{1, 1301.9} = 7.03$, $p = 0.008$) (Figure 2).

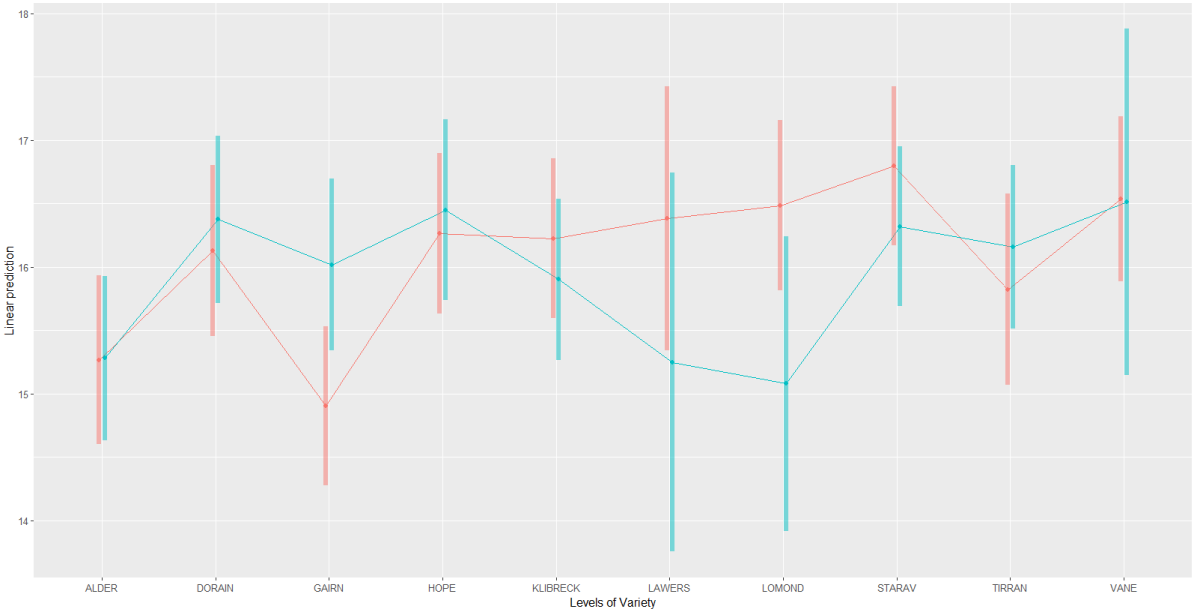

Figure 1. Interaction plot for Brix Scores by variety and nutrient spray treatment. Dots represent the estimated mean value and vertical lines the 95% confidence intervals. No nutrient spray treatment is in pink and nutrient spray treatment is in blue.

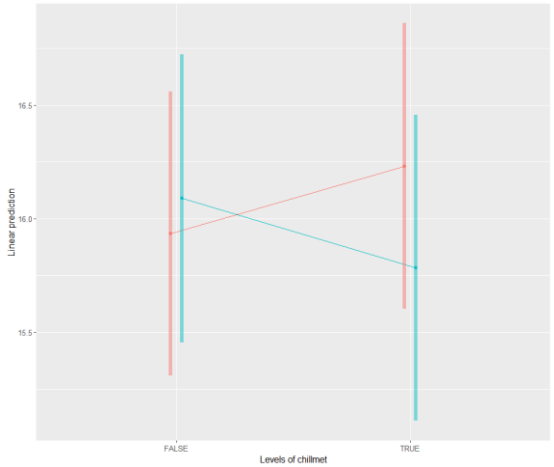

Figure 2. Interaction plot for Brix Scores by whether chill requirements were met and nutrient spray treatment. Dots represent the estimated mean value and vertical lines the 95% confidence intervals. No nutrient spray treatment is in pink and nutrient spray treatment is in blue.

Red fruit

Data was log transformed and again, variety explained the most variation in the proportion of Red Fruit ($F_{9,1907.34} = 35.97$, $p < 2.2e\text{-}16$). The effect of the nutrient sprays depend both on variety ($F_{9,1900.54} = 1.91$, $p = 0.46$) (Figure 3). and whether chill requirements had been met ($F_{1,1396.23} = 11.84$, $p = 0.00059$) (Figure 4). Application of nutrient sprays was associated with lower weight of red berries in Ben Lawers and higher weights in Ben Gairn. There was no difference in Red berry weight when the chilling requirement had not been met, but when it had, application of the nutrient sprays was associated with a higher weight of red berries.

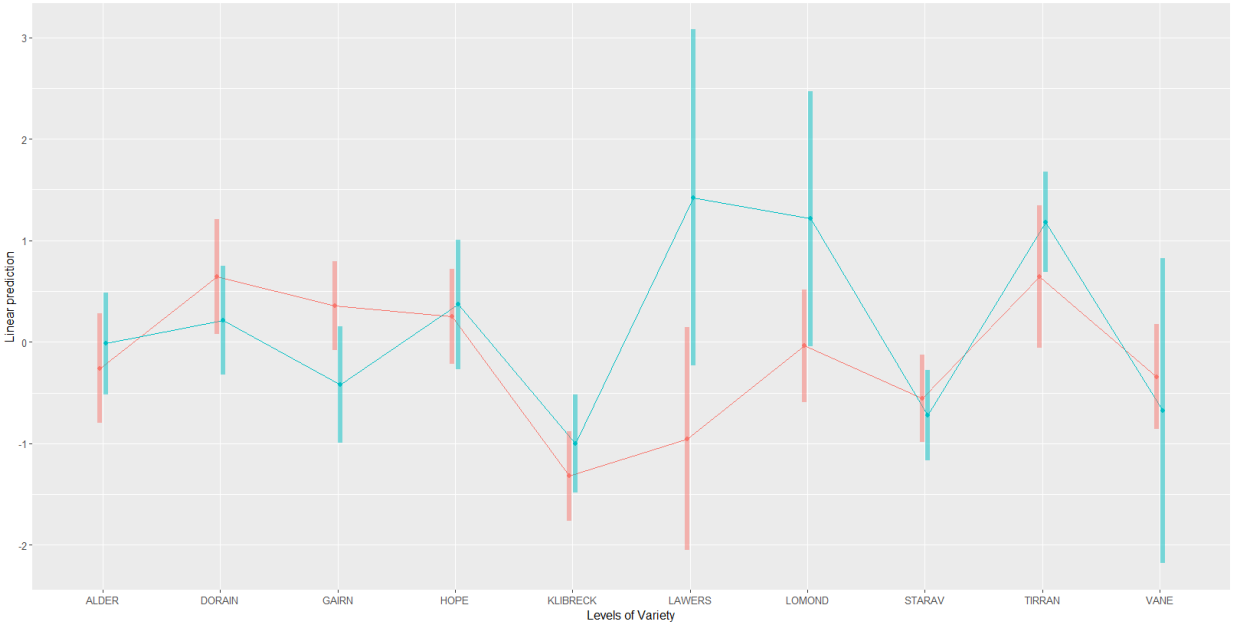

Figure 3. Interaction plot for log(Red Berry Weight) by variety and nutrient spray treatment. Dots represent the estimated mean value and vertical lines the 95% confidence intervals. No nutrient spray treatment is in pink and nutrient spray treatment is in blue.

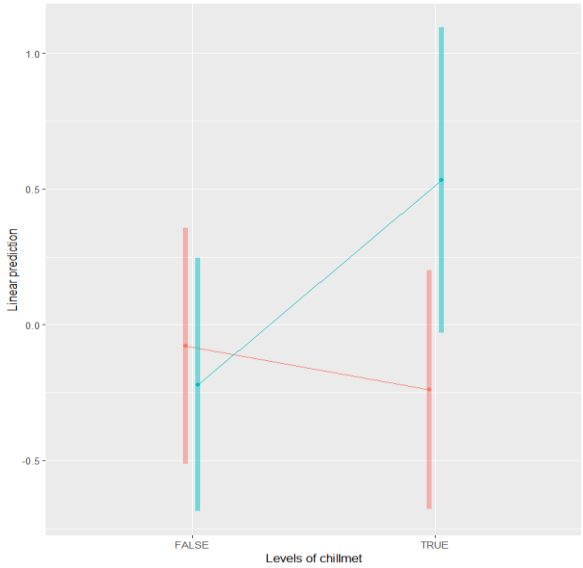

Figure 4. Interaction plot for log (Red Berry Weight) by whether chill requirements were met and nutrient spray treatment. Dots represent the estimated mean value and vertical lines the 95% confidence intervals. No nutrient spray treatment is in pink and nutrient spray treatment is in blue.

Quality Index

Quality index scores are percentages so are transformed by arcsin(sqrt(QI/100)) as is common with proportion and percentage data with values at the boundary. Variety had the greatest explanatory power ($F_{9,1881.36} = 42.20$, $p < 2.2e\text{-}16$). The effect of meeting the chilling requirement depended on Variety ($F_{8,1855.52} = 8.23$, $p = 5.25e\text{-}11$) and nutrient spray treatment ($F_{9,1291.93} = 6.08$, $p = 0.014$) with the three-way interaction also significant (($F_{2,1900.43} = 5.96$, $p = 0.0026$) (Figure 5). In general application of nutrient spray treatment was found to have little effect on quality scores, but it was beneficial in Ben Gairn if chill requirements were not met as quality index scores were maintained, but if no nutrient spray treatment was applied both Ben Dorain and Ben Gairn had significantly lower quality scores.

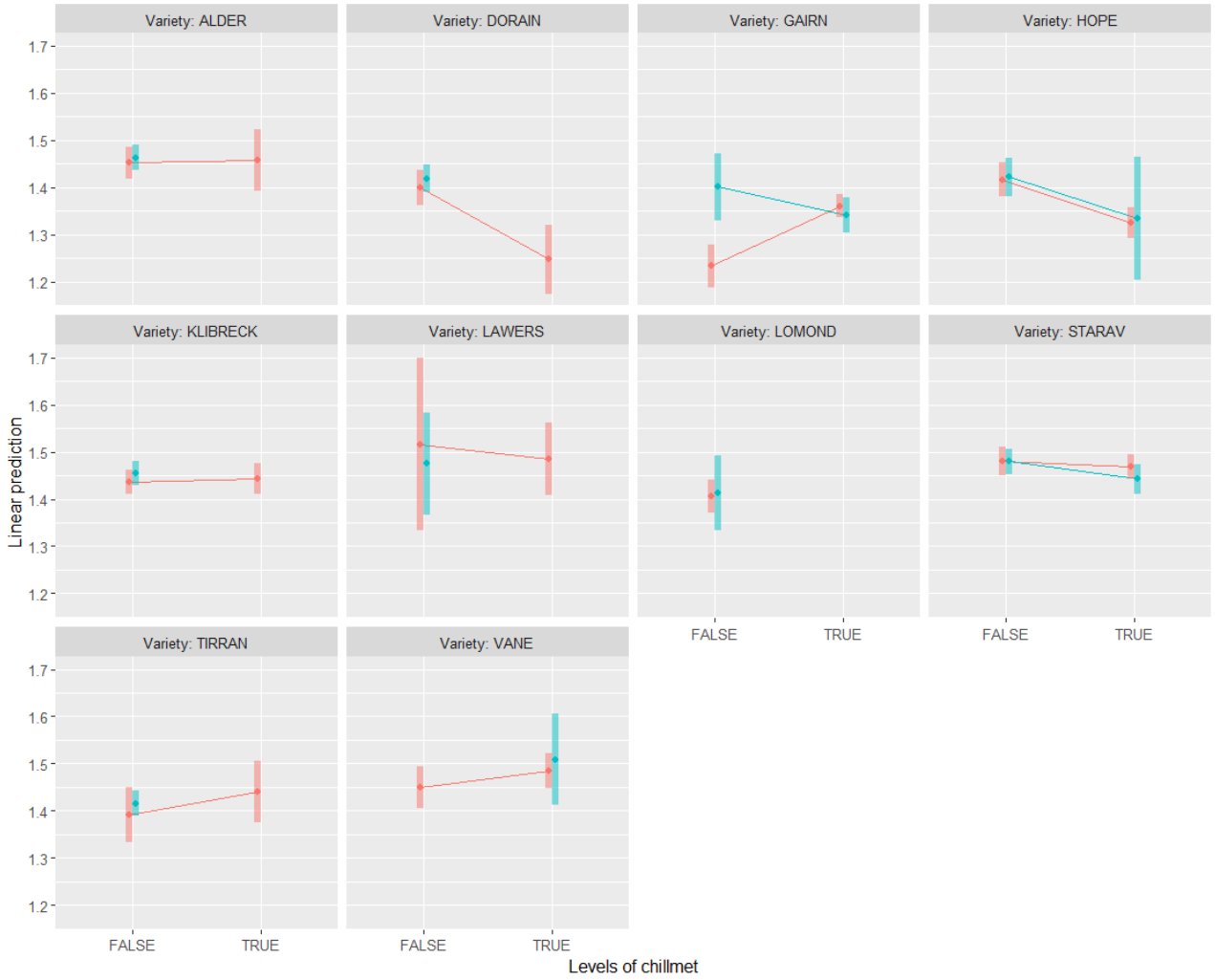

Figure 5. Interaction plot for Quality Index by Variety, whether the chill requirement is met and nutrient spray treatment. Dots represent the estimated mean value and vertical lines the 95% confidence intervals. No nutrient spray treatment is in pink and nutrient spray treatment applied is in blue. Chill requirements were never met for Ben Lomond and several varieties have confounding between chill requirement and application of nutrient spray treatment. In general application of nutrient spray treatment was found to have little effect but it was beneficial in Ben Gairn if chill requirements were not met as quality index scores were maintained, but if no nutrient spray treatment was applied both Ben Dorain and Ben Gairn had significantly lower quality scores.

Botrytis, Green, Shrivelled and Sun scorched Fruit

There were few samples with green or shrivelled or sun scorched fruit present, so analyses were restricted to the most widely grown varieties – Ben Gairn, Ben Klibreck and Ben Starav and the probability of the presence of at least some green, shrivelled and sun scorched fruit considered. There was insufficient evidence to support and effect of dormancy breaking treatment or chilling on the probability of a sample containing fruit in these conditions, though there were hints that where chill requirement is met, nutrient spray treatment may increase the risk of sun scorching. This must be heavily caveated by the exploratory nature of the analysis and limited samples with sun scorching. For most varieties there were very few samples with botrytis. The only exception was Ben Gairn where at least 40% of samples had at least some Botrytis infested fruit and this was more common when the chilling requirement had been met.

Conclusions

The analysis performed has less power than would have been the case with split-crop trials where the effect of grower and location variability would have been far better controlled. None the less, it is clear that the impact of applying nutrient spray treatments varies by variety and is of no benefit when chill requirements are met. In fact, it may be of disbenefit. It was not possible to consider yield or increases in vigour which have been observed in the field, so the study has focussed on measures of quality.

Ben Gairn benefited from bark applied nutrient spray treatments showing an increase in BRIX score and a decrease in red berries, when chilling requirements were not met, preventing a significant drop off in quality scores. Ben Lomond showed a decrease in BRIX score and an increase in red berries when nutrient spray treatments were applied despite never achieving the required chill accumulation.

In general, there appears to be a decrease in BRIX and an increase in Red Berries where chill requirements were met and nutrient spay treatments were applied. However, these observations should be carefully caveated because crops subject to nutrient spray treatments came from different locations than those where no treatment was applied and hence were subject to different soils, climatic conditions, and management practices. It is clear from the temperature data in Kent that local climatic conditions can be very variable. The threshold of 7C for chilling accumulation is known to be crude and no model (or data) was available for temperature conditions after March 2020.