Evaluation of Engulf® adjuvant with nitrogen for breaking dormancy in blackcurrant (*Ribes nigrum*)

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Abstract During the 2013 spring two different nitrogen sources (calcium nitrate and Break-N™) were applied using a motorised knapsack sprayer to dormant blackcurrants with and without the addition of a super penetrant surfactant (Engulf®) for dormancy breaking. Trials were conducted in Nelson at two grower sites, consisting of Ben Ard and Magnus blackcurrant varieties. Bud break and flowering was advanced by 5-10 days with the combination of the super penetrant surfactant and either nitrogen source. A Nitrogen source applied alone did not influence bud break or flowering. The length of flowering was condensed on Magnus and a more even and earlier fruit maturity occurred on both varieties with the combination of the super penetrant surfactant and nitrogen. The importance of these findings for the blackcurrant industry is discussed.

Keywords blackcurrant, Engulf®, nitrogen, dormancy breaking, fruit.

INTRODUCTION

The New Zealand blackcurrant industry consists of three main varieties, Ben Ard, Ben Rua and Magnus. These three varieties make up 85% of the planted area and produce approximately 8,000 tons of fruit annually (A. Tier, Blackcurrant NZ Inc., personal communication). One of the objectives in New Zealand blackcurrant (*Ribes nigrum* L.) breeding work is to produce lower winter chill varieties (Snelling & Langford 2002, 2003; Snelling et al. 2005). High winter chill blackcurrant varieties sometimes have patchy or uneven bud break (Jones & Brennan 2009). This often progresses through to spread out flowering, which allows a greater period of potential infection from *Botrytis cinerea*. This is the key disease affecting blackcurrants (Langford 1998), which if not controlled, can reduce yield (Walter et al. 2007). Blackcurrant fruit as they mature turn from green to black. Commercial growers harvest blocks with one pass mechanical pick and

try to obtain the maximum percentage of mature black fruit with higher sugar and characteristics favourable to processors and markets (Langford & White 1995). Fruit drop does occur when fruit become over ripe and this results in reduction of yield.

In the 2012 growing season a small preliminary trial to determine the effect of the super penetrant, organosilicone adjuvant, Engulf® (Etec Crop Solutions Ltd, Auckland, New Zealand) in combination with calcium nitrate on blackcurrant growth and development was undertaken. This found significant differences in bud break, fruit maturity and size (J.T. Smith, unpublished data). These outcomes could be a valuable technique for use in the blackcurrant industry. Not only could this assist in breaking dormancy of high winter chill varieties, but a more uniform bud break makes targeting fungicides to prevent disease more effective. Earlier or more condensed bud

break tends to allow a more uniform ripening of blackcurrant fruit as all berries are of a similar age.

Given these potential advantages to blackcurrant production from a single application, more investigation into the combination of Engulf® and different nitrogen sources was considered worthwhile. Using agrichemicals to break dormancy is not unusual as much of the New Zealand kiwifruit industry uses this technique to maximise vine productivity and fruit quality (Gaskin et al. 2006). This paper reports on the effects of two different nitrogen sources applied with and without Engulf® in the 2013 growing season on blackcurrants.

MATERIALS AND METHODS

Two commercial blocks of blackcurrants in Nelson, New Zealand, were chosen for this trial. One block in Sunrise Valley, Upper Moutere contained 13-year-old 'Magnus' variety plants, while the other block in Tapawera contained 5-year-old 'Ben Ard' variety plants. From each block two rows were selected and 10 m long treatment plots established.

Treatments were applied to the Ben Ard plots on 23 August 2013 using an Echo motorised knapsack sprayer with two TYR8003VK Teejet cone nozzles and an effective water rate of 500 litres/ha. The five treatments consisted of untreated (Control), Break-N™ (15 litres/ha; BN) and calcium nitrate (25 kg/ha; Cal), both with and without Engulf® (1 litre/ha; BN+E, Cal+E). Break-N™ (Etec Crop Solutions Ltd) is a free flowing liquid containing 223 g/litre nitrogen and 90 g/litre calcium designed specifically for use with Armobreak® to enhance bud break in kiwifruit (Anonymous 2011). For the Magnus block, only three treatments, Control, BN+E and Cal+E, were applied and this was done on 19 August 2013 using the same application equipment and water rate.

Both blocks were approximately 4 weeks from normal bud break at the time of treatment application with no bud movement noticeable. All treatments were replicated four times at each block. All other agrichemical applications during the season were applied as per normal to all rows in the blocks.

Five randomly chosen blackcurrant canes were assessed for bud break from each plot, on 25 September for the Magnus and 27 September for

the Ben Ard block. The number of buds open and showing green tissue was recorded and compared to the total number of buds on a cane. From 7 October to 1 November the amount of flowering was estimated every 3–7 days on both blocks. For each plot this involved visually estimating the percentage of flowering at points every 2 m along the row. These flowering percentages were plotted over time for a specific treatment and a regression line established to determine the slope values. The time, in days, between 20% and 80% flowering were then calculated from these slope values. On the 10 December at the Magnus block and 13 December at the Ben Ard block all fruit were removed off five randomly selected canes in each treatment plot. All fruit from each plot was then graded into green, coloured and black colour categories and weighed. These weights were then used to determine the proportion of fruit in each colour category. An analysis of variance was performed on the number of buds open and proportion of berries in each colour category. Least significant differences (LSD) were calculated to test if treatment means differed significantly. This analysis and the flowering regression were performed on Analyse-it, version 2.26, 2012 statistical computer package.

RESULTS

There were significantly more buds open on nitrogen plus Engulf®-treated plants than those which received nothing or only nitrogen. At the Ben Ard block, the BN+E and Cal+E treatments had a mean of 77.1% and 83.0% of their buds open respectively when compared to BN and Cal treatments (37.6% and 44.7% buds open) (Table 1). The Control was similar to nitrogen alone. The three treatments at the Magnus block were all significantly different from each other. The BN+E had the highest mean number of buds open with 68.2% (Table 1), while the Control treatment had the least number of buds open (19.2%). The Cal+E treatment was intermediate.

Flower development was clearly different between two groups of treatments at the Ben Ard site. The BN+E and Cal+E treatments had almost identical flower development (Figure 1). These two treatments had over 10% flowering at the first assessment and throughout the flowering

Table 1 Mean percentage of buds open for each treatment on the Ben Ard (27 September) and Magnus (25 September) blocks. Treatments with the same letter do not differ significantly ($P=0.05$).

Treatment	Ben Ard (n=20)			Magnus (n=20)		
	Mean	SE	LSD	Mean	SE	LSD
BN	37.6	3.2	a			
Cal	44.7	2.9	a			
Control	38.2	2.7	a	19.2	3.0	a
BN+E	77.1	2.5	b	68.2	2.9	c
Cal+E	83.0	1.7	b	56.2	3.9	b
P-value		<0.0001			<0.0001	

were 5–7 days earlier than any other treatments. The Control, BN and Cal treatments were similar in their flower development (Figure 1).

The number of days between 20% and 80% bloom calculated from the regression slope was similar between all treatments at the Ben Ard block. A difference of 0.85 days was found between the longest flowering treatment, BN, and the shortest flowering treatment Cal+E (Table 2). The Magnus block also had distinct differences between treatments in the number of days between 20% and 80% boom. The Cal+E treatment had 9.34 days calculated between these bloom parameters compared to 10.16 and 11.37 days for the BN+E and Control treatments respectively (Table 2). This is a reduction of 2.03 days between the longest and shortest flowering treatments.

The proportion of berries in each colour category was distinctly different in each treatment at the Ben Ard block. The BN+E and Cal+E treatments had 6.0% or fewer green berries, 18% coloured berries and approximately 77% black

berries (Table 3). These two treatments were significantly different from all others in each colour category. In comparison, the BN and Cal treatments had approximately 23% green, 29% coloured and 46% black berries. The Control had approximately one-third of berries in each category with the proportion of green berries being significantly higher than that of BN or Cal treatments (Table 3).

At the Magnus block the BN+E and Cal+E treatments were significantly different from the Control in all three berry categories, with the proportion of green and coloured fruit being significantly lower and the proportion of black fruit being significantly higher than that of the Control (Table 4). The BN+E and Cal+E treatments were not statistically different in all three berry categories (Table 4).

DISCUSSION

The ability of a nitrogen source with the addition of Engulf® to dramatically influence bud break on plants has not been published before. This

Figure 1 Flowering percentage for the five treatments at the Ben Ard block between the 7 and 29 October 2013.

novel combination caused earlier bud break on both blackcurrant varieties in this trial. Clearly the ability of Engulf® to aid nitrogen penetration into tissues is important as treatments that did not contain Engulf® had similar bud break to those of untreated plants. Why BN+E treatment achieved earlier bud break than the Cal+E treatment on Magnus compared to Ben Ard is not known. The Magnus block was 8 years older than that of the Ben Ard. Older bushes have thicker and more lignified canes compared to young plants. A liquid

form of nitrogen, like Break-N™ may provide better penetration with Engulf® into older wood when compared to calcium nitrate. However, this was the only significant plant response difference between the two nitrogen sources in all trial assessments.

Flower development was clearly earlier by at least 5 days on treatments that received Engulf® plus a nitrogen source on Ben Ard. This is logical as earlier bud break generally results in earlier flowering (Atkinson et al. 2013). An

Table 2 Calculated days between 20% and 80% blackcurrant flowering for each treatment using the regression slope values ($y = \text{time}$ and $x = \text{percentage bloom}$) for the Ben Ard and Magnus blocks.

Treatment	Slope	R ² value	Days between 20% and 80% bloom
Ben Ard block			
BN	$y = 1.142 + 0.1875x$	0.89	11.33
Cal	$y = 1.023 + 0.1887x$	0.88	11.32
Control	$y = 2.011 + 0.1835x$	0.91	11.01
BN+E	$y = -1.505 + 0.1861x$	0.78	11.17
Cal+E	$y = -1.077 + 0.1823x$	0.78	10.48
Magnus block			
Control	$y = 4.566 + 0.1895x$	0.90	11.37
BN+E	$y = -1.342 + 0.1693x$	0.88	10.16
Cal+E	$y = 0.2439 + 0.1556x$	0.86	9.34

Table 3 Mean proportion of fruit in each colour category as a percentage of the total fruit for each treatment at the Ben Ard site on 13 December 2013. Treatments with the same letter do not differ significantly ($P=0.05$).

Treatment	Green berries			Coloured berries			Black berries		
	Mean	SE	LSD	Mean	SE	LSD	Mean	SE	LSD
BN	23.9	3.4	b	28.8	4.2	b	47.3	7.3	a
Cal	23.5	1.5	b	30.4	5.1	b	46.0	6.3	a
Control	33.6	3.3	c	29.8	1.7	b	36.6	3.3	a
BN+E	6.0	1.1	a	17.7	3.3	a	76.4	3.6	b
Cal+E	4.2	0.9	a	17.9	2.3	a	78.0	2.7	b
P-value	<0.0001			0.0360			<0.0001		

Table 4 Mean proportion of fruit in each colour category as a percentage of the total fruit for each treatment on at Magnus site on 10 December 2013. Treatments with the same letter do not differ significantly ($P=0.05$).

Treatment	Green berries			Coloured berries			Black berries		
	Mean	SE	LSD	Mean	SE	LSD	Mean	SE	LSD
Control	31.8	2.7	b	33.9	3.9	b	34.3	5.9	a
BN+E	9.6	5.2	a	12.9	4.3	a	77.5	3.9	b
Cal+E	4.0	0.5	a	19.2	2.2	a	76.7	2.6	b
P-value	0.0006			0.0070			<0.0001		

earlier flowering could be both an advantage and disadvantage for commercial blackcurrant growing. If it resulted in flowering in a better weather window that was warmer and drier then that is likely to flow into a better fruit set and potential yield. Conversely if the earlier bud break pushed flowering into a cooler, wetter period then a poorer yield may result. During flowering in large commercial blackcurrant properties there are often time pressures to apply agrichemicals for disease prevention within a suitable weather window. Having the ability to alter flowering by 5 or more days in one block compared to another would reduce this time pressure as not all blocks would need to be treated on the same day. This could greatly enhance pesticide coverage by not needing to apply sprays in windy or marginal weather conditions.

A more condensed flowering occurred on Magnus plants treated with Engulf® and a nitrogen source. This resulted in a 2-day shorter period between 20% and 80% flowering on the E+Cal treated plants compared to the Control. The Ben Ard treatments did not show the same trend. This may be due to unusual weather conditions in Tapawera during the end of flowering. Every day between the 17 and 21 October reached above 20°C for more than 2 h (Hyatt and Sons weather station, Motueka Valley Highway, Tapawera). This would have dramatically increased flower development regardless of treatment. The Engulf® plus a nitrogen source treatments were already over 80% bloom when this warm period began so would not have been influenced to the same extent as the other treatments.

A more condensed flowering period could dramatically improve disease control. A single application of a fungicide will cover a greater proportion of the target tissues since a greater proportion will be at a suitable development stage. Commercial blackcurrant growers tend to target two fungicide applications over bloom, one early and one late, to protect against botrytis (J. Grierson, Grierson Horticultural Management Ltd, personal communication). Walter et al. (2007) found that cyprodinil and fludioxonil (Switch®, Syngenta Crop Protection) applications had to be within 3 days before or after a botrytis infection event to improve fruit set. With a condensed flowering

two fungicide applications, one at 20% bloom and another at 80%, would cover the majority of the flowering period. The New Zealand blackcurrant industry has a policy of ensuring all blackcurrant juice concentrates are free from pesticide residues (Langford 2005). A longer flowering period would result in young green berries and just opened flowers on the same blackcurrant plant. Applying a fungicide specifically for flowering and having fruit present may elevate the risk of residues being found at harvest. A more condensed bloom reduces this risk without comprising disease protection, since a greater proportion of flowering or fruiting tissues are at the same age.

When the fruit maturity assessments were conducted, Engulf® plus nitrogen source treatments in both varieties clearly had a higher proportion of fruit in the black category than the control. This is most likely in response to earlier bud break leading to earlier flowering and hence earlier fruit maturation. Fruit maturity and sugar content are important considerations for growers, with both parameters governing the optimum time to harvest (Langford & White 1995). Having all fruit at a similar maturity is obviously an advantage as there is less waiting for later fruit to ripen. In varieties that tend to drop fruit when they become over mature this could be critical. Ripe berries would not be lost while waiting for other berries to become mature, hence there is less potential loss in yield. Having fruit all at a similar maturity as a result of condensed bloom would influence the sugar content of any juice produced. Sugar content or brix is especially important for some key buyers. For example GlaxoSmithKline, who purchases blackcurrants for its Ribena brand, requires fruit to be 13 brix or higher before harvest. Green berries have a lower brix. If a higher proportion of the fruit are at a green or immature stage at harvest, the lower overall brix would affect grower return.

Earlier maturity and harvest of blackcurrants from influencing bud breaking could possibly improve currant clearwing (*Synanthedon tipuliformis* Lepidoptera: Sesiidae) suppression. This stem boring insect is serious pest of blackcurrant causing fruit yield losses of 25% (Hardy 1981). Flights of adult insects occur between early December and end of January with

peak flights and egg laying on canes occurring in early January (Langford et al. 2004). Due to potential residues in harvested fruit, the use of insecticides to control this pest at the most effective timing is prohibited. Pheromone mating disruption is the main strategy for clearwing suppression. The average harvest date on two grower properties, Ben Ard in Tapawera (R. Reynolds, personal communication) and Magnus in the Moutere (K. Eggers, personal communication), is 9 January. Shifting harvest forward by 5-10 days with dormancy breakers may allow for better timing of insecticide applications post harvest. This in combination with mating disruption could significantly reduce the impact of this pest on blackcurrants.

Overall the ability to influence plant responses with Engulf® and a nitrogen source could be a valuable combination in the blackcurrant industry. The findings in this trial have the potential to significantly impact on disease and pest control, harvest management, yield and financial return for the blackcurrant industry in the future.

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