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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.

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Report authorised by:

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GROWER SUMMARY

Headline

- Blackcurrant herbicides do not significantly affect yield or most fruit quality parameters.

Background and expected deliverables

The number of herbicides approved for use in blackcurrants has diminished in recent years due to the EU review and harmonization of crop protection products. The recent loss of dichlobenil (Casoron) has had a significant effect on weed control in UK blackcurrant plantations and there has been a resulting increase in broad-leaved and perennial weeds. Docks (*Rumex* spp.), creeping thistle (*Cirsium arvense*), couch grass (*Elymus repens*) and mallows (*Malva sylvestris & M. neglecta*) are becoming particularly prominent.

Their presence in blackcurrant plantations can not only compete with the crop for light, water and nutrients, they can impede machine harvesting and contaminate the harvested crop. There is also concern that the yield and quality of fruit can be affected both by high levels of weed infestation and conversely, the use of traditional herbicide treatments. Since fruit quality is crucial to the juice processing industry, it is important to understand the impact of perennial weeds and herbicides on fruit quality.

This project aimed to provide clear information and a better understanding of how perennial weeds affect blackcurrant fruit yields and quality.

The objectives of the work were to:

1. Assess the impact of herbicide use on weed-infested plots on harvesting quality and fruit yield.
2. Correlate fruit quality factors, such as Vitamin C, sugars and organic acids with various treatments and an untreated crop.

Summary of the project and main conclusions

Herbicide treatments were tested for their ability to control weeds and their effect on fruit quality in well-established blackcurrant during 2012. The trial was conducted at East Adamston Farm, Muirhead, Angus, Scotland courtesy of Andrew Husband.

Seven-year-old blackcurrant cv. 'Ben Dorain' was used for the trial. Plots were 9 m long by 1 m wide, centered on a single row of blackcurrant bushes; two adjacent rows were used for the trial.

Herbicide combinations, napropamide (Devrinol) + pendimethalin (Stomp) or metribuzin + flufenocet (Artist), were applied as a directed spray to the soil on 13 March using an air-pressurized backpack sprayer. Because these herbicides do not have post-emergence activity on weeds, all plots, including non-treated control plots, had previously been treated with diquat on 1 March to remove emerged weed foliage.

Initial weed cover within three 50 by 50 cm quadrats/plot was estimated on 29 February prior to herbicide application and again on 4 April and 22 May, 1 and 2 months after treatment (MAT), respectively. Plots were then hand-weeded on 13 June and 4 July to minimize the effect of weed interference on berry production.

Plots were harvested using the grower's machine harvester on 2 August and berries from each plot were weighed in the field. Additionally, 50-ml berry samples were collected from each plot and frozen at -80 C until used for fruit quality analyses.

The experimental design was a randomized complete block with three replicates.

Full details of fruit quality sampling are included in the Science Section of this report.

Herbicide use

There were no significant differences in weed cover in the treatments prior to herbicide application (29 February evaluation).

- Two weed species were most numerous in the plots: common groundsel (*Senecio vulgaris*, annual) and willowherb (a compilation of several *Epilobium* species, both annual and perennial, and *Chamerion angustifolium*, a perennial). These species accounted for 75 to 84% of all species recorded in the plots at the February evaluation.

- Artist and Stomp + Devrinol mix reduced weed cover by 75 and 35%, respectively, by 3 weeks after treatment (WAT, 4 April evaluation). At that time, both products were controlling 93% of common groundsel seedlings, but there was no influence on willow-herb.

- By 10 WAT (May evaluation), Stomp + Devrinol mix was still providing 69% common groundsel control, but control with Artist was similar to the untreated control.

- Willow-herb control at 10 WAT with Stomp + Devrinol mix and Artist was 80 and 87%, respectively; these products were controlling primarily seedling willow-herb plants of the annual *Epilobium* species, not the perennial *Chamerion* species.

- Herbicide treatment did not significantly affect total weed cover at 10 WAT, although total weed density was reduced from 45 to 68% by these herbicides.

- Herbicide treatments did not affect berry yield in this trial, although there was a trend toward lower yield in treated plots. This may indicate a degree of herbicide phytotoxicity to blackcurrant, or simply be due to differences in vigour of the tested bushes prior to herbicide application.

Data on herbicide use and effects is listed in Tables 1 and 2 of the Science Section of this report.

Fruit quality parameters

Most fruit quality parameters were not significantly affected by herbicide treatment in this trial. The only statistically significant effect was an increase in total sugar content of fruit from blackcurrant treated with Stomp + Devrinol mix compared with fruit from non-treated bushes or

those treated with Artist. All measured sugars (glucose, fructose, and sucrose) displayed a similar pattern (data not shown).

Although not statistically significant, other trends in the fruit quality data included a tendency toward higher polyphenol content, lower anthocyanin content, fewer organic acids, and greater vitamin C content in non-treated blackcurrant; fruit also tended to be fewer and larger on non-treated bushes. Despite the tendency toward lower yield in Artist-treated plots, juice yield was numerically highest from those fruit. There was no clear relationship between herbicide treatment and juice ºBrix or pH.

Data on the effect of herbicide use on fruit quality parameters are listed in Table 2 of the Science Section of this report.

Main conclusions

- Stomp + Devrinol mix and Artist provided at least 10 weeks pre-emergence control of common groundsel and willowherb species.

- Herbicides did not significantly affect yield or most fruit quality parameters, although total sugar was increased by treatment with Stomp + Devrinol mix.

Financial benefits

Given the results of this one-year project, it is difficult to calculate the exact financial benefits of weed control in blackcurrant plantations. However, given that plantation establishment costs amount to £4,000 per hectare and plantations can take up to three years to reach full production, any delay in reaching full production, which might be caused by weed competition, will result in lost revenue in the early life of a plantation and increase the time taken to pay off the establishment costs. This work has also demonstrated that herbicides did not significantly affect yield or most fruit quality parameters.

Actions points for growers

- No action points for growers have arisen from this project.

SCIENCE SECTION

Introduction

Perennial weeds are an increasing problem in soft fruit production worldwide. Control of them is usually challenging and results are not fully satisfactory. In Europe, herbicide availability is decreasing due to the implementation of new regulations: for example, the most effective product providing season-long weed control, Casoron (dichlobenil), was recently withdrawn. It is certain that there will be similar withdrawals in years to come, and it is therefore timely for UK fruit growers to seek alternative products and methods to improve control of perennial weeds in their plantations.

Blackcurrant plantations are especially vulnerable to perennial weed infestations due to the long-establishment of most plantations. There has been a significant increase in broad-leaved biennial and perennial weed growth in blackcurrant fields across the UK this year (2011), especially dock (*Rumex* spp.), creeping thistle (*Cirsium arvense*), couch grass (*Elytrigia repens*) and mallows (*Malva sylvestris & M.neglecta*). Weeds such as these impact negatively on plant growth, mainly due to resource competition, and can impede machine harvesting. Furthermore, there is concern among fruit processors and growers that the yield and quality of fruit can be affected by both certain herbicide treatments and conversely by high levels of weed infestation. Since fruit quality is crucial to the juice processing industry, it is important to understand the impact of perennial weeds and herbicides on fruit quality.

It can therefore be seen that there is an urgent need for research outlining methods and products that could be utilised in crop protection programmes to support UK blackcurrant growers in perennial weed control.

Aim and objectives

This work aimed to provide clear information and a better understanding of how herbicides affect blackcurrant fruit yields and quality.

The objectives of the study were to:

1. Assess the impact of herbicide use on weed-infested plots on harvesting quality and fruit yield.

2. Correlate fruit quality factors, such as Vitamin C, sugars and organic acids with various treatments and in untreated crop.

Materials and methods

Herbicide treatments were tested for their ability to control weeds and their effect on fruit quality in well-established blackcurrant during 2012. The trial was conducted at East Adamston Farm, Muirhead, Angus, Scotland courtesy of Andrew Husband.

Seven-year-old blackcurrant cv. 'Ben Dorain' was used for the trial. Plots were 9 m long by 1 m wide, centered on a single row of blackcurrant bushes; two adjacent rows were used for the trial.

Herbicide combinations, napropamide + pendimethalin or metribuzin + flufenocet, were applied as a directed spray to the soil on 13 March using an air-pressurized backpack sprayer (Fig. 1). Because these herbicides do not have post-emergence activity on weeds, all plots, including non-treated control plots, had previously been treated with diquat on 1 March to remove emerged weed foliage.

Fig. 1. Initial herbicide application

Fig. 2. Weed counts in early spring

Initial weed cover within three 50 by 50 cm quadrats/plot was estimated on 29 February (Fig. 2) prior to herbicide application and again on 4 April and 22 May, 1 and 2 months after treatment (MAT), respectively. Plots were then hand-weeded on 13 June and 4 July to minimize the effect of weed interference on berry production.

Plots were harvested using the grower's machine harvester on 2 August and berries from each plot were weighed in the field. Additionally, 50-ml berry samples were collected from each plot and frozen at -80 C until used for fruit quality analyses.

Three-berry subsamples were extracted for organic acid and sugar identification and quantification on 16-20 August and for vitamin C quantification on 27-28 September.

Total fruit polyphenols were measured on 7 September and total anthocyanin on 18 September using a spectrophotometer.

Sugars were identified and quantified on 29-30 August and organic acids were identified and quantified on 12-14 September, both using HPLC. Fruit remaining following extraction were processed for juice ºBrix score and pH on 26-27 September.

The experimental design was a randomized complete block with three replicates. Data were analyzed using SAS, and means were separated using Fisher's Protected LSD (P = 0.05).

Results and discussion

There were no significant differences in weed cover in the treatments prior to herbicide application (Table 1, 29 February evaluation).

- Two weed species were most numerous in the plots: common groundsel (*Senecio vulgaris*, annual) and willow-herb (a compilation of several *Epilobium* species, both annual and perennial, and *Chamerion angustifolium*, a perennial). These species accounted for 75 to 84% of all species recorded in the plots at the February evaluation.
- Artist and Stomp + Devrinol reduced weed cover by 75 and 35%, respectively, by 3 weeks after treatment (WAT, 4 April evaluation). At that time, both products were controlling 93% of common groundsel seedlings, but there was no influence on willow-herb.
- By 10 WAT (May evaluation), Stomp + Devrinol was still providing 69% common groundsel control, but control with Artist was similar to the nontreated check.
- Willow-herb control at 10 WAT with Stomp + Devrinol and Artist was 80 and 87%, respectively; these products were controlling primarily seedling willow-herb plants of the annual *Epilobium* species, not the perennial *Chamerion* species.
- Herbicide treatment did not significantly affect total weed cover at 10 WAT, although total weed density was reduced from 45 to 68% by these herbicides.

Table 1. Weed cover (%) and weed counts (plants/m^2) before and after herbicide application to blackcurrant cv. 'Ben Dorain'

Herbicide[z] and date of evaluation	Rate		Weed cover	Willow-herb	Common groundsel	Total weeds[y]
	kg ai/ha	product/ha	%	plants/m^2	plants/m^2	plants/m^2
29 February, prior to application						
Stomp + Devrinol	1.3 + 3.2	2.9 L + 7 L	20	28.2	0.4	34.2
Artist	1.7	3.3 kg	29	22.2	3.6	33.4
Nontreated	---	---	31	30.0	2.9	43.8
$LSD_{0.05}$	---	---	NS	NS	NS	NS
4 April, 3 weeks after treatment						
Stomp + Devrinol	1.3 + 3.2	2.9 L + 7 L	8 b	0.8	0.9 b	273.8
Artist	1.7	3.3 kg	3 c	0.3	0.9 b	177.6
Nontreated	---	---	12 a	0.9	13.6 a	333.3
$LSD_{0.05}$	---	---	4.2	NS	6.2	NS
22 May, 10 weeks after treatment						
Stomp + Devrinol	1.3 + 3.2	2.9 L + 7 L	21	12.2 b	15.8 b	40.2 b
Artist	1.7	3.3 kg	11	7.8 b	57.8 a	69.6 b
Nontreated	---	---	25	61.6 a	50.4 a	125.8 a
$LSD_{0.05}$	---	---	NS	16.1	4.0	29.5

[z]All plots were treated with Retro (diquat) at 2L/ha (400 g diquat/ha) + nonionic surfactant (0.25%, v/v) 1 March 2012; residual herbicides applied to appropriate plots 13 March 2012.

[y]Most of the total weeds counted in the plots at the April evaluation were seedling blackcurrant.

Herbicide treatments did not affect berry yield in this trial (Table 2), although there was a trend toward lower yield in treated plots. This may indicate a degree of herbicide phytotoxicity to blackcurrant, or simply be due to differences in vigour of the tested bushes prior to herbicide application.

Table 2. Berry yield[z] and fruit quality parameters from blackcurrant cv. 'Ben Dorain' treated with herbicides in late dormancy (2012)

Treatment[y]	Rate Product /ha	Berry yield kg/plot	Berry no no./ sample	Mean berry weight g/berry	Juice yield L/ tonne	ºBrix	pH	Total polyphenol mg/100ml	Total anthocyanin mg/500ml	Total sugars g/L	Total organic acids g/500ml	Vitamin C mg/100 ml
Stomp + Devrinol	2.9 L + 7 L	16.23	27.7	0.80	518	16.1	2.47	4037	3868	1674 a	91	0.61
Artist	3.3 kg	13.71	27.0	0.79	536	15.8	2.44	4022	3645	1334 b	85	0.72
Non-treated	---	17.56	25.7	0.88	530	16.1	2.46	4102	3315	1430 b	66	0.83
Pr > F	---	0.06	0.94	0.72	0.83	0.76	0.66	0.98	0.71	0.02	0.49	0.44

Means within a column and followed by the same letter, or not followed by a letter, are not significantly different ($P < 0.05$).

[z]Plots harvested 2 August 2012.

[y]All plots were treated with Retro (diquat) at 2L/ha (400 g diquat/ha) + nonionic surfactant 0.25%, v/v) 1 March 2012; residual herbicides applied to appropriate plots 13 March 2012.

Similarly, most fruit quality parameters were not significantly affected by herbicide treatment in this trial. The only statistically significant effect was an increase in total sugar content of fruit from blackcurrant treated with Stomp + Devrinol compared with fruit from non-treated bushes or those treated with Artist (Table 2). All measured sugars (glucose, fructose, and sucrose) displayed a similar pattern (data not shown).

Although statistically non-significant, other trends in the fruit quality data included a tendency toward higher polyphenol content, lower anthocyanin content, fewer organic acids, and greater vitamin C content in non-treated blackcurrant; fruit also tended to be fewer and larger on non-treated bushes. Despite the tendency toward lower yield in Artist-treated plots, juice yield was numerically highest from those fruit. There was no clear relationship between herbicide treatment and juice ºBrix or pH.

Conclusions

- Stomp, Devrinol, and Artist provided at least 10 weeks of control of seedling common groundsel and willow-weed species.
- Herbicides did not significantly affect yield or most fruit quality parameters, although total sugar was increased by treatment with Stomp + Devrinol.