The Impact of Early Cropping on Subsequent Yield of Highbush Blueberry

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Abstract

The effect of early cropping (no blossom removal the first two years) and in-row spacing at 0.45 m and 1.2 m were studied in 'Duke', 'Bluecrop', and 'Elliott' blueberries (*Vaccinium corymbosum* L.) grown on raised beds for 4 years. In a separate study, the effect of early cropping on yield of 'Bluecrop' on "flat ground" was studied for 8 years. No yield was produced on the control plants in the planting year (year 1) and the year after planting (year 2). In 'Bluecrop' grown on flat ground, cumulative yield at 0.45m was 106% higher than at 1.2 m over the 8 years of the study. Early cropping increased cumulative yield by 17% from years 3 through 8 compared to control plants. In a separate study of 'Bluecrop', 'Duke', and 'Elliott', however, plant growth at the start of year 3 was adversely impacted by early cropping. Early cropping reduced the dry weight of the root system, crown, and one- to three-year-old wood in all cultivars. 'Bluecrop' plants had less total dry weight than those of 'Duke' or 'Elliott'. Roots accounted for 30 to 45% of the total plant dry weight depending on cultivar. Early-cropping reduced root system weight 42% compared to control plants. Early-cropped plants had a lower percentage of fruit buds in 'Bluecrop' and 'Duke' than control plants. Early cropping reduced yield in year 3 by 18% in 'Bluecrop', 26% in 'Duke', and 54% in 'Elliott'. Yield of 'Elliott' in year 4 was still affected by early cropping. Cumulative yield (years 1 through 4) was not affected by early cropping in 'Bluecrop' or 'Duke', whereas in 'Elliott', cumulative yield was lower in early-cropped plants. Plants spaced at 0.45m produced 62% to 140% more yield than those spaced at 1.2m. 'Elliott' plants seemed less suited to high density planting due to their large total dry weight and large root system.

INTRODUCTION

Blueberry production has been increasing steadily in Oregon and Washington, USA with approximately 80 to 120 ha being planted annually, on average, over the last ten years. Growers have been following recommendations (Pritts and Hancock, 1992; Strik et al., 1993) in removing blossom buds to prevent fruit production the first two years after planting. This standard procedure, usually performed by pruning off blossom buds in the winter, is thought to be necessary to promote good root and vegetative growth (Dodge, 1981; Eck, 1988). There has been little published research on the impact of early cropping on subsequent growth and yield in blueberry. If growers were able to crop plants early (in years one and two), then they would not only derive some income from the fruit, but would save an estimated $125-$250/ha by not having to prune off the blossom buds.

Most of the mature hectarage in Oregon and Washington, USA is spaced at 1.2 m in the row with 3m between rows. However, growers are tending now to establish plantings at higher density, particularly at 0.8 to 0.9m in the row based, in part, on research done by Strik and Buller (2002). Moore et al. (1993), in a five-year spacing study with 'Bluecrop' and 'Blueray', found no differences between cultivars and that yield was highest at the 0.6 m spacing. Plants were not cropped early in his study. Strik

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and Buller (2002) found that cumulative yield of 'Bluecrop' from years three through seven was 104% higher at a 0.45m spacing than at 1.2m. Early cropping in combination with higher planting densities could mean faster economic returns for highbush blueberry growers.

The objectives of this study were to determine the effect of early cropping and in-row spacing on yield of 'Bluecrop', 'Duke', and 'Elliott'.

MATERIALS AND METHODS

Experiment One

A planting of 'Bluecrop' was established at the North Willamette Research and Extension Center (NWREC) in Aurora, Ore., USA in October, 1993. The planting site was fumigated with methyl bromide/chloropicrin, with sawdust and fertilizer (66 kg·ha^{-1} of N) incorporated prior to planting two-year-old container stock. The treatments were an in-row spacing of 0.45 or 1.2m (3m between rows) and early cropping (with or without blossom bud removal). In the control treatments (no crop in 1994 and 1995), blossom buds were pruned off the plants in October, 1993 and in February 1995 in addition to the standard pruning of removing weak, diseased or low growth (Strik et al., 1990). The early-cropped plants were not pruned in winter 1993/94 and 1994/95 other than to remove any diseased wood or very low growth. There were five replicates of each treatment combination arranged in a randomized complete block design.

Plots were harvested by hand from 1994-96 and by an over-the-row machine harvester (Littau Harvesters, Stayton, Ore.) from 1997-2000. Data collected included yield and average berry weight (25 berries per harvest).

Experiment Two

A new research planting was established at the NWREC in October, 1999. The planting site was fumigated with methyl bromide/chloropicrin, with sawdust and fertilizer (66 kg·ha^{-1} of N) incorporated and raised beds (~ 0.4 m high) formed prior to planting two-year-old container stock. The treatments were: cultivar (Duke, Bluecrop, Elliott); in-row spacing (0.45 m, 1.2 m); and early cropping. In the control treatments (no crop in 2000 and 2001), blossom buds were pruned off the plants in October, 1999 and in February 2001. There were five replicates of each treatment combination arranged in a randomized complete block design for a total of 60 plots. Each plot was 6 m long with 3 m between rows (13 or 5 plants per plot at the 0.45 m or 1.2 m spacing, respectively). The planting was flanked by guard rows.

Plots were harvested by hand. Data collected included yield, average berry weight (25 berries per harvest), and percent fruit bud set. In February, 2002 and 2003, one plant per plot was destructively harvested and divided into its parts and dry weights obtained.

RESULTS AND DISCUSSION

Experiment One

Yield in 1994 (year 1) was only 54 or 58 g·plant^{-1} at the 0.45 m and 1.2 m spacing, respectively. In 1995 (year 2), yield/plant was 160 and 350 g·plant^{-1} at 0.45 m and 1.2 m, respectively. Early cropping had no negative impact on the subsequent yield of 'Bluecrop' in this experiment. In fact, plants that were cropped in years 1 and 2 actually had an average of 17% ($P < 0.01$) higher cumulative yield than control plants from years 3 through 8. Cumulative yield at 0.45m was 106% higher than at 1.2m over the 8 years of the study. Thus, in this experiment, early cropping somehow stimulated subsequent production. Early cropping and in-row spacing had no effect on average berry weight (data not shown).

Experiment Two

1. Cultivar. 'Duke', 'Bluecrop', and 'Elliott' differed significantly in yield per

plant from year 1 through 4. Yield was reduced in all cultivars in 2003, due to poor weather during the pollination period. Cumulative yield per plant was 77% to 120% greater in 'Elliott' than in 'Bluecrop' or 'Duke' (Table 1). The cultivars differed in berry weight in all years of this study with 'Bluecrop' having the largest fruit and 'Elliott' the smallest (Table 2).

2. Spacing. In 2001, plants at 0.45 m had a greater yield/plant than those at 1.2 m in contrast to what was observed in 2002 and 2003 (Table 1). Plants were significantly larger at 1.2 m than at 0.45 m in February 2002 and 2003 and thus produced a greater yield. There was a significant cultivar by spacing interaction for cumulative yield per plant (Table 1). In the control, 'Bluecrop' produced a similar cumulative yield per plant at 0.45m and 1.2 m, whereas 'Duke' and 'Elliott' produced a higher cumulative yield on plants spaced at 1.2 m than those at 0.45 m (Table 1). Thus, 'Bluecrop' produced a 140% higher cumulative yield at 0.45m (36 $t \cdot ha^{-1}$) than at 1.2 m (15 $t \cdot ha^{-1}$) for plants that were not cropped early. 'Duke' produced 30 $t \cdot ha^{-1}$ at 0.45m, 97% greater than at 1.2m whereas 'Elliott' only produced 62% more yield at 0.45m (53 $t \cdot ha^{-1}$) than at 1.2m.

Thus, 'Elliott' seems to be less adapted to higher density planting perhaps because this cultivar has a relatively large root system. Spacing had no significant effect on the percentage of total plant dry weight accounted for by the roots ($P > 0.05$). In February 2003, the root system of 'Elliott' accounted for 45% of the total plant dry weight compared to 37% and 30% in 'Duke' and 'Bluecrop' respectively ($P \leq 0.0001$). In addition, the top to root ratio was the highest in 'Bluecrop' (2.5), moderate in 'Duke' (1.7) and the lowest in 'Elliott' (1.4; $P \leq 0.0001$). The smaller root system of 'Bluecrop' and the higher top:root ratio appear to make this cultivar well suited to higher density planting.

In-row spacing had an inconsistent effect on average berry weight. In 2000 and 2001, plants spaced at 0.45m produced larger fruit than those planted at 1.2 m (Table 2). In 2002, fruit were larger on plants at 1.2 m whereas in 2003 there was no effect of in-row spacing on berry weight (Table 2). There was no consistent correlation between berry weight and yield (data not shown).

3. Early Cropping. Yield of 'Bluecrop' in this experiment was similar in year 1, but 2.5 to 10 fold greater in year 2 than was observed in experiment one (Table 1). The difference in yield was likely due to the greater growth obtained on the raised beds in experiment two. In year 1, yield on all cultivars in experiment 2 was less than 0.7 $t \cdot ha^{-1}$, but may have been economical to harvest depending on the market and price obtained for the fruit. In winter 2000/01, after one year of early cropping, there was no treatment effect on the percentage of fruit buds per lateral (data not shown).

In 2001, yield per plant increased 8 to 16 fold, depending on the cultivar (Table 1). Yield per hectare ranged from 5 t in 'Duke' to 7 t in 'Bluecrop' and 'Elliott' spaced at 0.45m. Plants spaced at 1.2m in the row yielded from 2 $t \cdot ha^{-1}$ in 'Duke' and 'Bluecrop' to about 2.5 $t \cdot ha^{-1}$ in 'Elliott'. Thus, commercial growers would be able to recover a significant portion of planting establishment costs, by cropping plants in year 2.

Cropping in 2001, however, had negative effects on subsequent plant growth and percent fruit bud set. In February 2002, early cropping reduced the percent fruit buds in 'Bluecrop' from 52% to 40% (compared to control plants at 1.2m), in 'Duke', from 69% to 66%; there was no effect in 'Elliott' (62%). Total plant dry weight was affected by cultivar and early cropping, but not in-row spacing, likely because the canopy was not yet full at the 1.2m spacing. Plants cropped in 2000 and 2001 had a reduced dry weight of the root system, crown, and one-, two-, and three-year-old wood in February 2002, in all cultivars. In particular, early cropping reduced the weight of the root system by 42%, averaged over all cultivars and in-row spacing. 'Bluecrop' plants had less total dry weight than those of 'Duke' or 'Elliott' (data not shown).

Early cropping had a significant negative effect on yield per plant in 2002 (Table 1) because plants grew less in 2001 and due to the lower percentage of fruit bud set (in some cultivars). There was a significant early cropping by cultivar interaction with early cropping reducing yield in 2002 by 18% in 'Bluecrop', 26% in 'Duke', and 54% in

'Elliott'. This seems to support our hypothesis that early cropping is more of a stress on plants that have a high yield late in the growing season.

Plants that were cropped in 2000 and 2001, produced larger fruit than those that were not cropped early (Table 2) due to the strong negative correlation between berry weight and yield ($r = -0.56$; $P \leq 0.0001$; Table 1).

In February 2003, there was no effect of early cropping on fruit bud set. Cultivars differed in average percent fruit buds with 'Duke' having the highest (~ 55%) and 'Bluecrop' the lowest (~ 44%). In all cultivars, the percentage of fruit bud set was about 3 to 4% lower in plants spaced at 0.45 m than those at 1.2 m (i.e. 40% at 0.45 m compared to 44% at 1.2 m in 'Bluecrop'). Total plant dry weight was still less for early-cropped plants, particularly at the 1.2m in-row spacing in 'Elliott'. The percentage of total plant dry weight that was roots was not affected by early cropping (data not shown).

In 2003, cultivar, spacing and early cropping all had a significant effect on yield per plant (Table 1). Cultivar was the only factor affecting berry weight in 2003 (Table 2). Unfortunately, yield was reduced in 2003 as a result of poor weather during pollination.

Cumulative yield was significantly affected by early cropping (Table 1). However, there was a cultivar by early cropping interaction, because cumulative yield was similar between early cropped and control plants in 'Bluecrop' and 'Duke' whereas early cropping reduced yield 20% to 40% in 'Elliott', depending on in-row spacing (Table 1).

CONCLUSIONS

Young plants spaced at high density (0.45 m) compared to the more traditional spacing of 1.2 m produced from 62% to 140% more cumulative yield in this study, depending on the cultivar. 'Bluecrop' seemed to be the best adapted to higher density plantings and 'Elliott' the least, perhaps due to differences in the top:root ratio and total plant dry weight or size in these cultivars. Our results on the effect of in-row spacing on yield are similar to those reported by Strik and Buller (2002) in 'Bluecrop'.

In experiment two, early cropping produced economical yields, particularly in year 2 at 0.45 m (averaging 6.5 $t \cdot ha^{-1}$). In our first experiment, yield of 'Bluecrop' on flat ground was lower and plant vigor reduced; thus early cropping had no negative impact. We cannot explain why, in experiment one, early cropping stimulated subsequent yield. In experiment two, vigor and yield were greater on the raised beds. Thus, early cropping seemed to "stress" plants as evidenced by a reduced total plant dry weight, and fruit bud set after year 2. However, early cropping had less impact on 'Bluecrop' and 'Duke' than on 'Elliott', perhaps due to 'Elliott's higher yield and late fruiting season.

Early cropping is not recommended in these cultivars as there is no increase in cumulative yield (years 1 to 4). However, if income from fruit is needed in years 1 and 2, growers may be able to produce fruit on 'Bluecrop' and 'Duke' – provided yields are not too high.

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Tables

Table 1. The effect of cultivar, in-row spacing and early cropping on yield from 2000-2003 (and total cumulative yield) for plants established in 1999 at NWREC.

Treatment	Early Crop (yes/no)	Yield/plant (kg) 2000	2001	2002	2003	Cumulative
Duke						
0.45m	No	--	--	2.7	1.6	4.3
	Yes	0.096	0.75	2.1	1.5	4.2
1.2m	No	--	--	3.5	2.0	5.7
	Yes	0.086	0.66	2.5	2.0	5.3
Bluecrop						
0.45m	No	--	--	2.5	2.3	5.2
	Yes	0.066	1.1	2.3	2.0	5.2
1.2m	No	--	--	2.4	3.1	5.5
	Yes	0.061	0.82	1.7	2.0	5.1
Elliott						
0.45m	No	--	--	5.2	2.2	7.6
	Yes	0.092	1.0	3.4	1.8	6.0
1.2m	No	--	--	9.2	2.9	12.1
	Yes	0.095	0.95	4.3	2.3	7.1
Sig.[1]						
C		0.01	0.01	0.0001	0.01	0.0001
S		ns	0.05	0.0001	0.01	0.0001
EC		--	--	0.0001	0.01	0.0001
C x S		ns	ns	ns	ns	0.001
C x EC		--	--	0.0001	ns	0.0001
S x EC		--	--	ns	ns	0.05

[1]C=cultivar; S=in-row spacing; EC=early cropping; "x" indicates treatment interaction. P value is provided to indicate level of significance.

Table 2. The effect of cultivar, in-row spacing and early cropping on average berry weight from 2000-2003 for plants established in 1999 at NWREC.

Treatment	Early Crop (yes/no)	Berry weight (g) 2000	2001	2002	2003
Duke					
0.45m	No	--	--	1.66	1.62
	Yes	1.16	1.66	1.78	1.74
1.2m	No	--	--	1.72	1.60
	Yes	1.14	1.58	1.98	1.54
Bluecrop					
0.45m	No	--	--	1.66	1.86
	Yes	2.08	1.56	2.00	1.94
1.2m	No	--	--	1.78	1.74
	Yes	1.94	1.38	2.22	2.00
Elliott					
0.45m	No	--	--	1.18	1.50
	Yes	1.44	0.98	1.32	1.68
1.2m	No	--	--	1.36	1.06
	Yes	1.30	0.96	1.50	1.42
Sig.[1]					
C		0.001	0.001	0.001	0.001
S		0.05	0.05	0.01	ns
EC		--	--	0.001	ns
C x S		ns	ns	ns	ns
C x EC		--	--	ns	ns
S x EC		--	--	ns	ns

[1]C=cultivar; S=in-row spacing; EC=early cropping; "x" indicates treatment interaction. P value is provided to indicate level of significance.