Summer Pruning Differentiates Vegetative Buds to Flower Buds in the Rabbiteye Blueberry (*Vaccinium virgatum* Ait.)

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Pruning is a recommended cultural practice in blueberries (*Vaccinium* spp.) to maintain the balance between vegetative growth and reproductive development. Winter pruning is common and well-documented practice. Summer pruning, however, has been less studied. In this study, 5 primary shoots (PSs) were selected per treatment (pruning date) on 5 different bushes (replications) of the rabbiteye blueberry (*Vaccinium virgatum* Ait.) ‘Tifblue’ and half-length headed back during its active growth period from June through Nov. The hypothesis tested in this study was that summer pruning induces flower buds at the basal area of PSs, controls the plant canopy and makes it possible to harvest fruits in the next summer season from the same shoots. In this study, there were no significant differences observed among any treatments with respect to yield and fruit quality. Early summer pruning (June) stimulated secondary shoots (SSs) and later in autumn, terminal flower buds of these SSs produced fruits in the following year. However, no SSs were produced after summer pruning in Sept., and only vegetative buds that were at the basal area of PSs differentiated to flower buds and produced fruits in the following year. In conclusion, summer pruning can be practiced to complement or replace winter pruning and growers could decide the date of summer pruning in accordance with the size of plants’ canopies. Plants with smaller canopies can be pruned in June and those with bigger canopies can be pruned in Sept.

Key Words: canopy management, photoperiod, primary shoots (PSs), terminal bud.

Introduction

Pruning is a recommended practice in blueberries (family Ericaceae; genus *Vaccinium* spp.) to regulate the balance between vegetative growth and reproductive development (Kovaleski et al., 2015; Muller, 2011; Pescie et al., 2011). No pruning leads to smaller and fewer fruits (Hindle et al., 1957), excessively tall and difficult to harvest bushes (Krewer et al., 2004; Pescie et al., 2011), as well as decreasing vigor and node number in shoots (Pescie et al., 2011). An increasing number of productive shoots arising from canes reduces productive capacity if they are left unpruned for several years because shoots become thinner and shorter with fewer internodes. The number of flower buds and leaf buds are related to diameter, length, and number of internodes on the shoot. Shoots with a larger diameter and higher number of nodes have a better chance to develop more and stronger flower buds (Hanson et al., 2000; Jansen, 1997; Siefker and Hancock, 1986; Strik and Buller, 2005). Pruning improves light penetration into the canopy which increases the number of flower buds (Yanez et al., 2009). Cutting back vigorous shoots removes apical dominance and promotes lateral bud break during the same season (Banados et al., 2009). Winter pruning is well-documented in blueberry cultivation (Albert et al., 2010; Krewer et al., 2004; Muller, 2011; Siefker and Hancock, 1987). Gough (1991) reported that blueberries should be pruned annually during late winter and early spring in the northern USA. Summer pruning, however, has been less studied. Summer pruning consists of cutting back shoots during the plant’s active growth period from early summer through autumn.
The shoot growth pattern of blueberries is episodic and sympodial (Gough et al., 1978). In the first growth flush, most shoots come from axillary buds on the previous year’s growth (Gough et al., 1978). The number of growth flushes varies by cultivar, environmental conditions, and plant health (Gough et al., 1978). Flower buds are produced on primary, secondary, and tertiary shoots that are produced in the first, second, and third growth flushes (Lindberg, 2013). The reproductive buds of blueberries consist of terminal and lateral flower buds. The induction of flower buds from vegetative buds begins at the shoot apex and moves basically in response to a short day length with appropriate temperature (Darnell, 1991; Hall et al., 1970; Phatak and Austin, 1990). The amount of floral initiation was proportional to the duration of exposure to short days (Darnell, 1991) and was suppressed by high temperatures (Spann et al., 2004). Fruits are produced on one-year-old woods with reproductive buds in the apical area. Vegetative buds are located in the basal area (Galletta et al., 1990).

Both the timing and severity of summer pruning should be considered to obtain the desired results (Rana et al., 2011). Early summer pruning can result in excessive regrowth, late summer pruning can reduce cold-hardiness, and lack of pruning can reduce the amount of regrowth (Pescie et al., 2011; Williamson and Darnell, 1996). In Japan, the conventional winter pruning of vigorous rabbiteye blueberry plants is applied in two ways: (1) Severe cut back of vigorous shoots in which the productive apical area of the shoot is removed and no fruit can be harvested in the upcoming summer season from the same shoot. (2) Light heading back of shoots to maintain yield which results in expanding the unproductive parts and increasing the size of the plant’s canopy each year. Summer pruning with suitable timing and intensity can be the most suitable solution to this problem.

In Japan, the production and management of blueberry plants are often mainly based on experiments developed in other countries, especially the USA and Canada which are origin countries of cultivated blueberries. The agroclimatic and management conditions for blueberry cultivation in Japan is markedly different from those in the USA or Canada. Therefore, it is necessary to study the best management practice that is suitable for local agroclimatic and management conditions. The hypothesis tested in this study was that summer pruning induces flower buds at the basal area of primary shoots (PSs), controls the plant canopy, and makes it possible to harvest fruits in the next summer season from the same shoots. The objective of this investigation was to determine the effect of summer pruning dates on flower bud formation, yield, and fruit quality of the rabbiteye blueberry (Vaccinium virgatum Ait.) ‘Tifblue’.

**Materials and Methods**

Five field-grown 49 year old bushes of the rabbiteye blueberry (Vaccinium virgatum Ait.) ‘Tifblue’ were summer pruned from June to Nov. 2014 (viz. June 21, July 21, Aug. 21, Sept. 21, and Nov. 21). Five PSs per treatment (pruning date) were selected for each replicate (bush), and pruned in a half-length manner. The minimum and maximum height of bushes that were used in this study ranged from 2.64 to 2.78 m in July 2016, and the lengths of PSs just before summer pruning application are presented in Figure 1. In the following winter (22 Dec. 2014), the total number of leaf buds, flower buds and secondary shoots (SSs) per one year old summer pruned PSs were measured. To compare the effect of summer pruning with winter pruning, on 22 of March 2015 five PSs from each summer pruned bushes (replicates) were selected and conventional light winter pruning was applied; this was considered to be the control. The next summer (2015), the quality and quantity of harvested berries such as total soluble solids (TSS, ºBrix), titratable acidity (TA, %), berry diameter, berry weight, number of berries per flower bud, number of berry, and total berry weight per PSs were measured. Harvest was started on 7 July with six day intervals and lasted until 18 Aug. Mature berries with full-color development and that were blue at the pedicel base were harvested. Fruits from the first harvest were compared among treatments or between treatments and the control with respect to fruit quality, and total harvest with respect to fruit quantity. TSS and TA were determined using freshly prepared juice extracted by muslin cloth. The juice of 10 randomly selected healthy fruits per treatment per replication was extracted and the TSS was measured using a digital refractometer (PR-101α; ATAGO CO. LTD., Tokyo, Japan). TA was determined by the colored indicator method, diluting 1 mL juice to 5 mL distilled water and adding a drop of phenolphthalein, then titrating with...
For the diameter of fruits, 10 randomly selected first harvest berries per treatment per replication were measured using a digital caliper. Berry weight was measured using 10 randomly selected healthy berries from the first harvest per treatment per replication using a digital scale (TA3001JP; Ohaus Corporation, China). For the total number of fruits per flower bud, 5 flower buds per treatment per replication and 5 flower buds per the control per replication were randomly selected and the total number of fruits per flower bud were calculated and compared among treatments or between treatments and the control. For the total number of berries, as well as total berry weight per PSs, berry number, and weight of all harvest intervals were calculated and after the final harvest, total berry number and weight were divided by 5 (the number of PSs).

The study results were analyzed by Tukey-Kramer or Steel-Dwass statistical tools based on the test results of data normality. Differences at \( P < 0.05 \) were considered statistically significant.

### Results and Discussion

The date of summer pruning did not affect the number of leaf buds per PS in any treatments (Fig. 2). This result is probably related to the fact that bud concentrations mainly located on the apical area of PSs are removed by summer pruning and during the investigation period only internodes of PSs were elongated. By apical dominance elimination due to early summer pruning (June) SSs were stimulated, while late summer pruning (Sept.) only induced flower buds on PSs and no SSs were grown (Figs. 2, 3, and 4). The reaction of vegetative buds in response to the summer pruning dates differed by the stage of growth and depended on photoperiod. Histological studies confirmed that flower bud initiation occurred under an 8-h photoperiod and shortening day length, and vegetative growth on longer days (Pescie et al., 2011). These results were also confirmed by the report of Banados et al. (2009) in southern and northern highbush blueberries in which late summer pruning reduced lateral branching. Kovaleski et al. (2015) also reported that summer pruning of southern highbush blueberries in June and July in Florida generally increased the vigor of vegetative growth. In the present study, summer pruning differentiated vegetative buds to flower buds. The number of flower buds per PSs was affected by the treatments (pruning dates). Sept. pruning markedly induced flower

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**Fig. 2.** Effect of summer pruning dates on the number of leaf buds and secondary shoots (SSs) per primary shoot (PS). Different letters indicate significant differences (Steel-Dwass, \( P < 0.05 \)). NS indicates not significant. The bars indicate standard errors.

**Fig. 3.** Effect of summer pruning dates on the number of flower buds per primary shoot (PS). Different letters indicate significant differences (Steel-Dwass, \( P < 0.05 \)). The bars indicate standard errors.

buds in the basal area of PSs (Figs. 3 and 4), but very few flower buds were induced on the PSs after application of pruning in Nov. (Fig. 3). These results are more likely related to the photoperiod, the growth cessation induced by late summer pruning (Faust, 1989) and the dormancy induced by the low temperatures (Banados et al., 2009). It is well known that flower bud initiation in blueberries occurs during short days with suitable temperature (Darnell, 1991; Hall et al., 1970; Phatak and Austin, 1990). In the early summer pruning (June), fewer flower buds on the PSs appeared to be directly related to the number of SSs (Figs. 2 and 3). Summer pruning did not affect the quality or quantity of berries among the treatments or between treatments and the control such as TSS, TA, berry diameter, and berry weight (Table 1). The number of berries per flower bud, the total number of berries and total berry weight per PSs did not differ among treatments or between treatments and the control. Since early summer pruning stimulated the growth of SSs, these SSs also produced flower buds and consequently a similar number of fruits were obtained from all treatments. These results are probably more relevant to the similar number of leaves per PSs among treatments. There was a positive correlation between leaf number and fruit numbers in rabbiteye and southern highbush blueberries (Lyrene, 1991; Williamson and Miller, 2000). Suzuki et al. (1998) reported that as the leaf/fruit ratio reduced from 5:1 to 1:1 in highbush blueberries, the quality of berries declined.

The present study established the fact that summer pruning differentiates vegetative buds to flower buds in the rabbiteye blueberry which results in fruit harvest in the next summer season. Therefore summer pruning can be practiced as an alternative to, or complement with, winter pruning. June pruning stimulated SSs and these SSs produced fruits in the next summer season. After Sept. pruning, no SSs were grown but vegetative buds that were present at the basal area of PSs were differentiated to flower buds and consequently produced fruits in the next summer season. Therefore there was no difference observed with respect to yield and quality of fruits among treatments. The conclusion can be drawn is that Sept. is the best summer pruning time for canopy management in the rabbiteye blueberry, but farmers could decide the pruning date based on the size of plant canopies. Plants with smaller canopies can be pruned in June and those with bigger canopies can be pruned in Sept. Further studies are necessary to determine the appropriate intensity of summer pruning in the rabbiteye blueberry.

**Literature Cited**


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**Table 1. Effect of summer pruning dates on the yield and quality of harvested berries.**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>No. of fruit per primary-shoot</th>
<th>No. of fruit per flower bud</th>
<th>Total fruit weight per primary-shoot (g)</th>
<th>Fruit diameter (mm)</th>
<th>Fruit weight (g)</th>
<th>Total soluble solids content of the juice (°Brix)</th>
<th>Titratable acidity of the juice (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>27.2 NS*</td>
<td>4.2 NS*</td>
<td>158.8 NS*</td>
<td>15.1 NS*</td>
<td>1.6 NS*</td>
<td>11.9 NS*</td>
<td>1.1 NS*</td>
</tr>
<tr>
<td>July</td>
<td>34.8</td>
<td>4.4</td>
<td>188.5</td>
<td>15.2</td>
<td>1.7</td>
<td>11.9</td>
<td>1.2</td>
</tr>
<tr>
<td>Aug.</td>
<td>26.9</td>
<td>5.3</td>
<td>128.7</td>
<td>15.6</td>
<td>1.7</td>
<td>12.4</td>
<td>1.2</td>
</tr>
<tr>
<td>Sept.</td>
<td>26.9</td>
<td>6.0</td>
<td>166.6</td>
<td>15.9</td>
<td>1.8</td>
<td>12.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Nov.*</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Control (Mar.)</td>
<td></td>
<td>4.7</td>
<td>15.8</td>
<td>1.8</td>
<td>1.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

z: NS indicates not significant (Tukey-Kramer, $P<0.05$).
y: NS indicates not significant (Steel-Dwass, $P<0.05$).
x: The flower buds did not produce berries.
pruning on vegetative traits of two southern highbush blueberry cultivars. HortScience 50: 68–73.


