INFORME TÉCNICO Y DE DIFUSIÓN

VIII Symposium Internacional sobre cultivo de Vaccinium

FIA-FP-L-1-A-006

Enrique Acevedo Herl

Vial Berry Marketing S.A.

GOBIERNO DE CHILE
FUNDACIÓN PARA LA
INNOVACIÓN AGRARIA

INFORME TÉCNICO Y DE DIFUSIÓN

1. Antecedentes Generales de la Propuesta

Nombre
VIII Symposium Internacional sobre cultivo de Vaccinium

Código
FIA-FP-L-1-A-006

Postulante
Enrique Acevedo Herl

Entidad Patrocinante
Vial Berry Marketing S.A.

Lugar de Formación
Portugal (Oeiras)-España (Sevilla)

Tipo o Modalidad de Formación
Asistencia a Seminarios

Fecha de realización (Inicio y término)
3 al 8 de mayo 2004

Justificación y Objetivos de la Propuesta
Intercambio de información y discusión de temas relacionados con la producción y comercialización de especies del genero Vaccinium con los demás asistentes al Symposium

Resultados e Impactos Esperados

1. Contacto con breeders de los principales centros de investigación del mundo

2. Comprobar que la información con la que se trabaja en Chile es toda externa, lo que potencia el desarrollo de investigación propia.

3. Intercambio de experiencias con respecto a los últimos avances en investigación en producción.

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2. Breve Resumen de los Resultados:

Este tipo de Symposium es organizado por la Sociedad Internacional de Horticultura (ISHS) y se realiza cada 4 años en distintos países del mundo; el próximo se realizará en Oregon Estados Unidos el año 2008.

El symposium concentra principalmente a científicos que se encuentran investigando en distintas áreas del genero Vaccinium, cuya principal especie son los Arándanos "blueberry" y en segundo lugar los arándanos o "Cranberry", los demás vaccinium, aún cuando algunos tienen valor comercial, tienen gran importancia ya que se puede usar como banco de germoplasma, para cruzamientos que permitan el mejoramiento de las especies con importancia comercial.

Durante el symposium se dieron a conocer los temas científicos más relevantes que están siendo desarrollados en el mundo, los que fueron entregadas a los participantes a través de material escrito que contiene el resumen de las exposiciones y que en el mes de Diciembre del 2004 será complementado con un libro con los temas ampliados que la organización hará llegar a cada participante. Por ahora se adjunta el documento con los resúmenes al presente informe.

Hubo 48 presentaciones orales, 56 paneles y 130 participantes de 28 países, de los cuáles el 67% eran científicos, se destaca que la delegación por país más numerosa fue la de Estados Unidos, y la Chilena estuvo a nivel de las 3 o 4 más importantes superando, incluso a los "locales".

La masiva participación de Chile, está relacionada a la importancia económica que ha alcanzado el cultivo de arándanos en el país, y la necesidad de especialización y desarrollo de tecnología local que se requiere para continuar el desarrollo de este cultivo en un escenario competitivo.

Las actividades realizadas fueron desarrolladas en España y Portugal bajo un programa que se detalla a continuación:

PORTUGAL

1. Mejoramiento, genética y desarrollo de la planta.
2. Técnicas de producción, crecimiento de la planta y cosecha.
3. Nutrición, micorrizas y propagación.
4. Día de campo en que se visitaron huertos de producción más tardía

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ESPAÑA

1. Plagas y enfermedades.
2. Manejos de post-cosecha, calidad de fruta y nutricionales.
3. Aspectos Económicos y de Marketing.
4. Día de campo en el área de Huelva (España, suroeste de Sevilla) zona costera, existen 180 hectáreas de arándanos y se visitó 1 huerto del cual se adjuntan fotos en el CD anexo.

Entre los temas tratados, se considera que los más interesantes desacuerdo a las expectativas y necesidades de Vital Berry Marketing S.A., fueron los presentados por los científicos de los Estados Unidos, Paul Lyrene de la Universidad de Florida y mejorado de Southern Higbush y James Hancock de la Universidad de Michigan con la descripción del mejoramiento de los Northern Higbush en el mundo, del cual el forma parte.

De las exposiciones de científicos chilenos, se destaca la del Dr. Jorge Retamales de la Universidad de Talca con el tema "Efecto Fisiológico con el uso de malla de sombreamiento en Arándano Alto en la variedad Berkley en la zona centro sur de Chile" y la Dra. Pilar Bañados de la Pontificia Universidad Católica con el tema "Producción de Arándanos en Sudamérica".

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3. Itinerario de Trabajo Realizado: presentación de acuerdo al siguiente cuadro:

Fecha	Actividad	Objetivo	Lugar
3/5/04	VIII Symposium	inicio	Portugal (oeiras)
8/5/04	VIII symposium	termino	España(Sevilla)

4. Resultados Obtenidos:

1. Se pudo observar el comportamiento del arándano bajo plástico.
2. Se realizó Intercambio de opiniones con los principales genetistas del mundo, logrando concertar visitas a los centros de interés principalmente en Estados Unidos.
3. Entender que el tema de la Nutrición (fertilización) en Arándanos es un aspecto que impacta fuerte y directamente en los resultados obtenidos (calidad y productividad).
4. Compartir con otros expertos la visión de que el consumo de arándanos crece en el mundo, así como la plantación.

En CD adjunto se incorporan un set de fotografías que respaldan los puntos expuestos anteriormente.

5. Aplicabilidad:

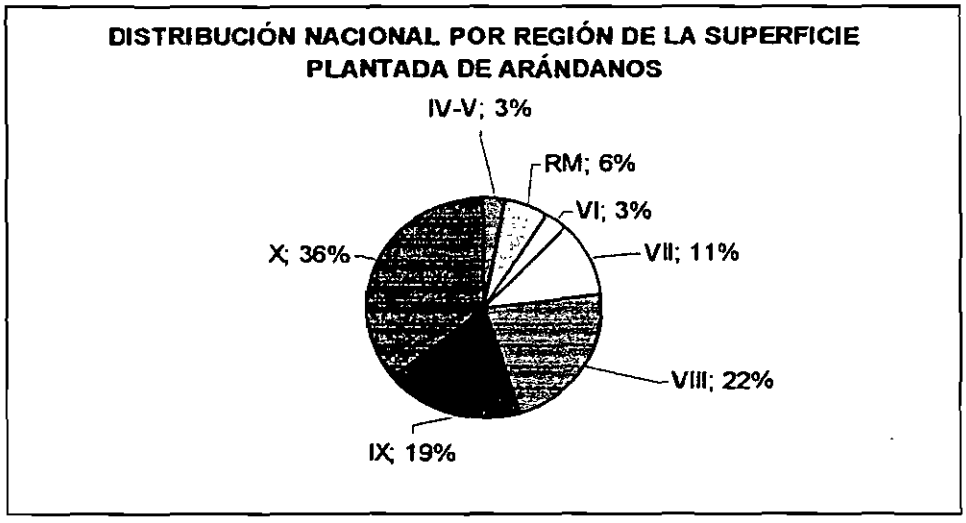
Se estima que actualmente en Chile existen 3.200 hectáreas de arándanos ,300 hectáreas de arándanas y aproximadamente 30 há de otros Vaccinium.

Respecto del cultivo de arándanos, estos se encuentran distribuidos entre la IV y X región, desatacándose que las principales regiones de mayor superficie son la VIII, IX y X, tal como se observa en el gráfico adjunto.
El Arándano se encuentra distribuido desde la IV a la X Región:

CUADRO: DISTRIBUCIÓN SUPERFICIE PLANTADA DE ARÁNDANOS EN CHILE

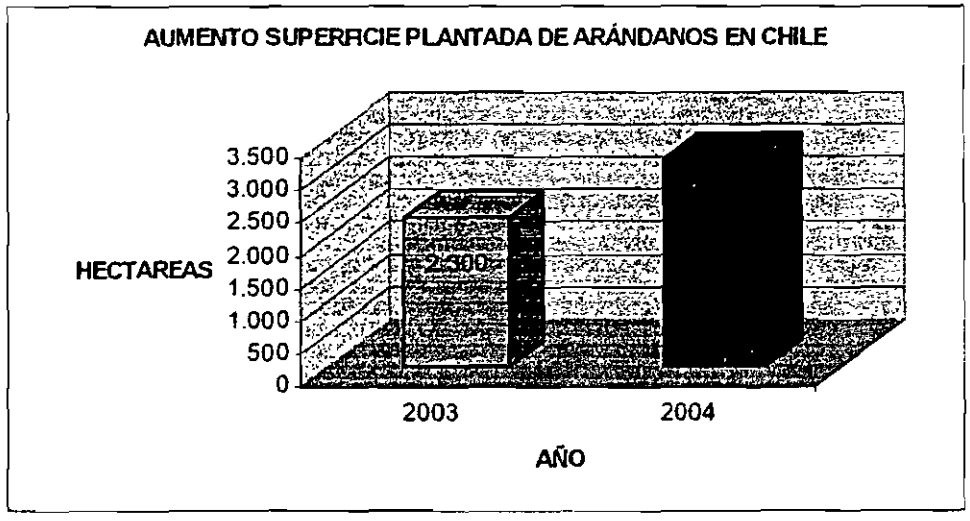
	REGIONES						
	IV-V	RM	VI	VII	VIII	IX	X
DISTRIBUCIÓN	3%	6%	3%	11%	22%	19%	36%

GRAFICO 1



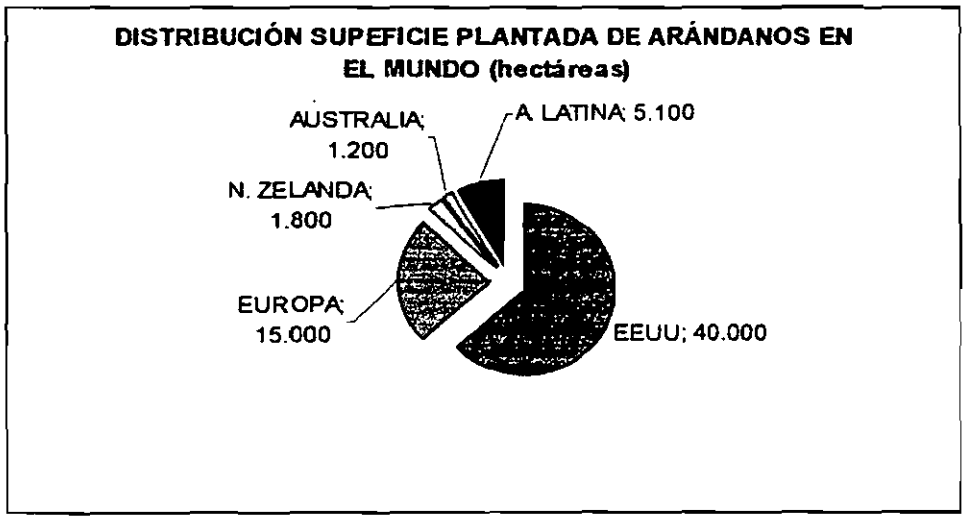
Del gráfico anterior se observa claramente el desarrollo que ha tenido el cultivo en el sur y centro sur de Chile, que se ha debido principalmente a los buenos resultados que se han obtenido hasta la fecha con las variedades que se han manejado, las que son básicamente, Oneal, Duke, Bluecrop, Brigitta y Elliot.

GRAFICO 2



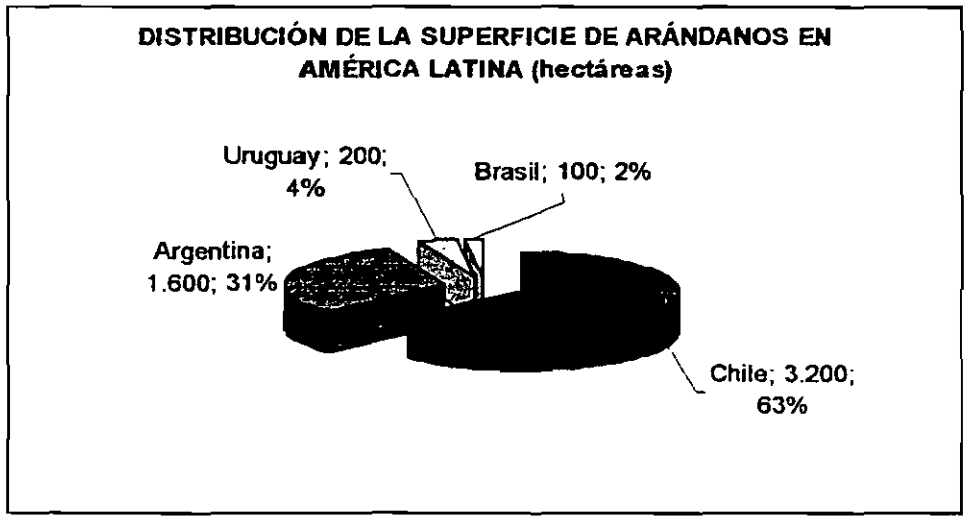
Se observa también un gran crecimiento en la superficie de plantación, representada en el Gráfico 2 la que corresponde sólo a una estimación sin saber con exactitud la superficie real plantada, el incremento entre el año 2003 y 2004 es del orden del 39% , siendo una tasa de crecimiento que preocupa si se proyecta en el tiempo.

GRAFICO 3



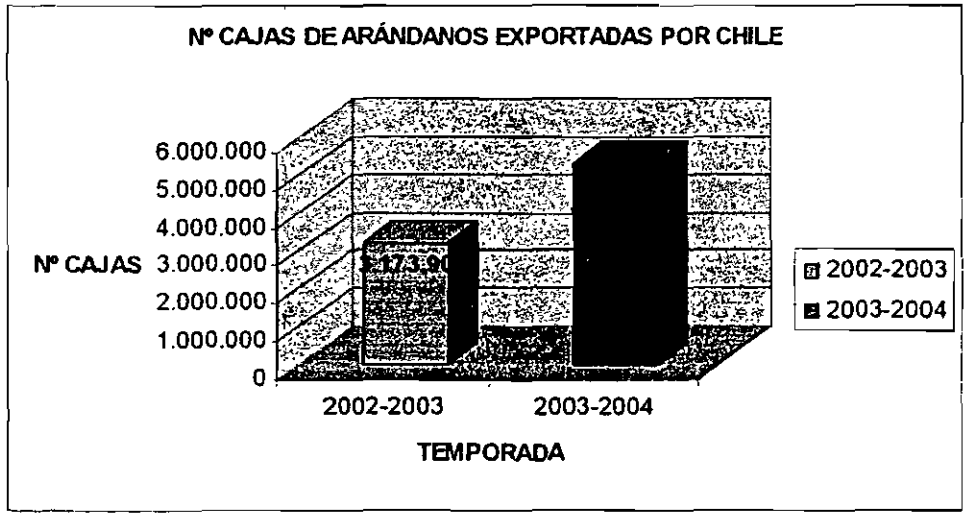
La superficie de arándanos en el mundo, Gráfico 3 es de aproximadamente 63.000 que se distribuyen principalmente en EEUU, Europa, América Latina, Nueva Zelanda y Australia. Se destaca dentro de este escenario la participación de América Latina con un 8% de la superficie mundial y a un 63% de la superficie que entra en producción en la misma época que corresponde a Australia y Nueva Zelanda.

GRAFICO 4:



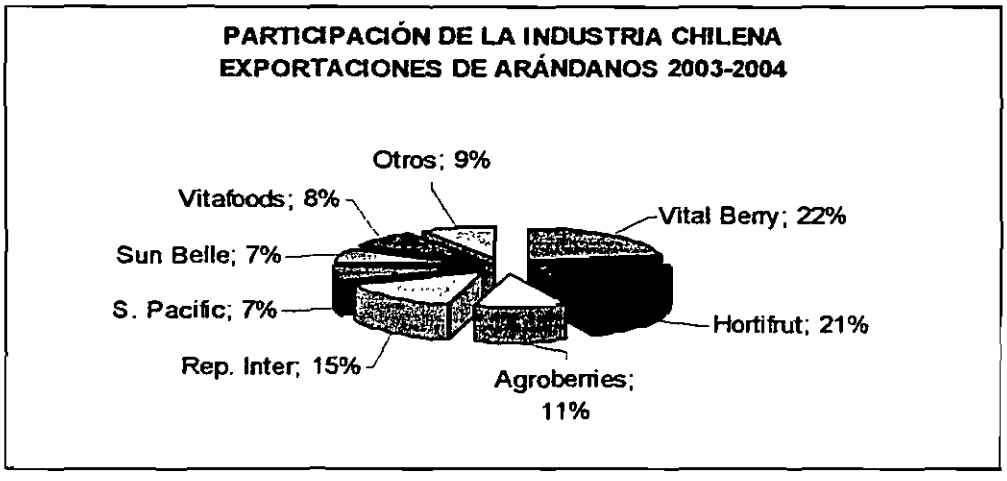
Tal como se observa en el Gráfico 4, actualmente Chile es el principal país de América Latina en cuánto a superficie plantada, por lo mismo es urgente el desarrollo de investigación nacional, para maximizar la eficiencia del cultivo deacuerdo a las condiciones específicas agroclimáticas de la región en que se desarrolla el cultivo, ya que hasta la fecha se ha importado conocimiento, experiencia y tecnología de otros países, principalmente de Estados Unidos para el manejo de variedades y del cultivo.

GRAFICO 5:



Se estima que Chile es el principal exportador de arándanos del mundo, y tal como se observa en el gráfico 5, se ha incrementado fuertemente la oferta exportable de arándanos, registrándose en la última temporada un aumento del 60% respecto de la temporada anterior.

GRAFICO 6



Actualmente en Chile, la principal exportadora de arándanos es Vital Berry Marketing S.A. que tuvo una participación del 22% de la industria con 1.176.739 cajas.

En resumen, de acuerdo al escenario competitivo de este producto, en que se prevé un aumento importante de la oferta tanto de chile como de otros países de América Latina, principalmente Argentina y Urguay, se estima que se requieren unidades productivas que maximicen su eficiencia y que puedan realizar economías de escala que les permitan soportar la caída de los precios internacionales, con una buena rentabilidad.

Por lo anterior es urgente trabajar en la creación de variedades de arándanos deacuerdo a la realidad agroclimática chilena, teniendo en cuenta las características de la demanda y aumentar el grado de especialización en el manejo agronómico del cultivo de acuerdo a las distintas zonas en que se encuentra ubicado el cultivo.

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6. Contactos Establecidos: presentación de los antecedentes de los contactos establecidos durante el desarrollo de la propuesta (profesionales, investigadores, empresas, etc.), de acuerdo al siguiente cuadro:

Institución/Empresa	Rut	Persona de Contacto	Rut	Cargo	Fono/Fax	Dirección	E-mail

7. Detección de nuevas oportunidades y aspectos que quedan por abordar:

Chile organizará en Diciembre 2005 (1 al 7) el 9º Symposium de Rubus y Ribes (frambuesas, moras y zarzaparrillas) se aprovechó el symposium al que se asistió para dejar invitados a todos los especialistas a enviar sus trabajos.

Se realizaron contactos con científicos en áreas específicas para seguir en comunicación abierta y visitar sus centros de investigación a a

VBM viene implementando hace varios años una fuerte internacionalización la que la obliga como empresa a estar presente en todos los eventos importantes en Chile y el mundo del rubro.

Así es como estará en la 4ª. Convención mundial de países productores de frambuesas que se realizará en Mount Evelyn, Victoria, Australia el 18 y 19 de Noviembre 2004.

Los aspectos que se deben abordar a partir de este momento son principalmente generar una base de investigación y datos nacionales que nos independice cada vez más de lo que sucede en Estados Unidos.

8. Resultados adicionales:

Se ratificaron convenios con:

1.
2.

6.contactos Establecidos (tarjetas de presentación)

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Douven

"De koningin der bessen."
Een zeer gezonde lekkernij
met geneeskrachtige waarden.

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Expuso.

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9. Material Recopilado:

Tipo de Material	Nº Correlativo (si es necesario)	Caracterización (título)
Impreso Abstracts	1	Programme book of abstracts
impreso	2	Blue Berry production in south america
impreso	3	Nitrogen in HighBush blueberries
impreso	4	BB production y ph modification
impreso	5	BB studies
Impreso	6	Impact of Early cropping
Impreso	7	Manipulation of annual growth cycle of BB using photoperiod

10. Aspectos Administrativos

10.1. Organización previa al inicio de la actividad de formación

a. Apoyo de la Entidad Patrocinante

__x__ bueno _____ regular _____ malo

Existe una larga relación entre FIA y VBM

b. Información recibida por parte de FIA para realizar la Postulación

___x_ detallada _____ aceptable _____ deficiente

Se entregaron detalladamente explicados desde la forma de postular hasta los plazos involucrados

c. Sistema de Postulación al Programa de Formación de FIA

_____ adecuado __x__ aceptable _____ deficiente

9.Material Recopilado

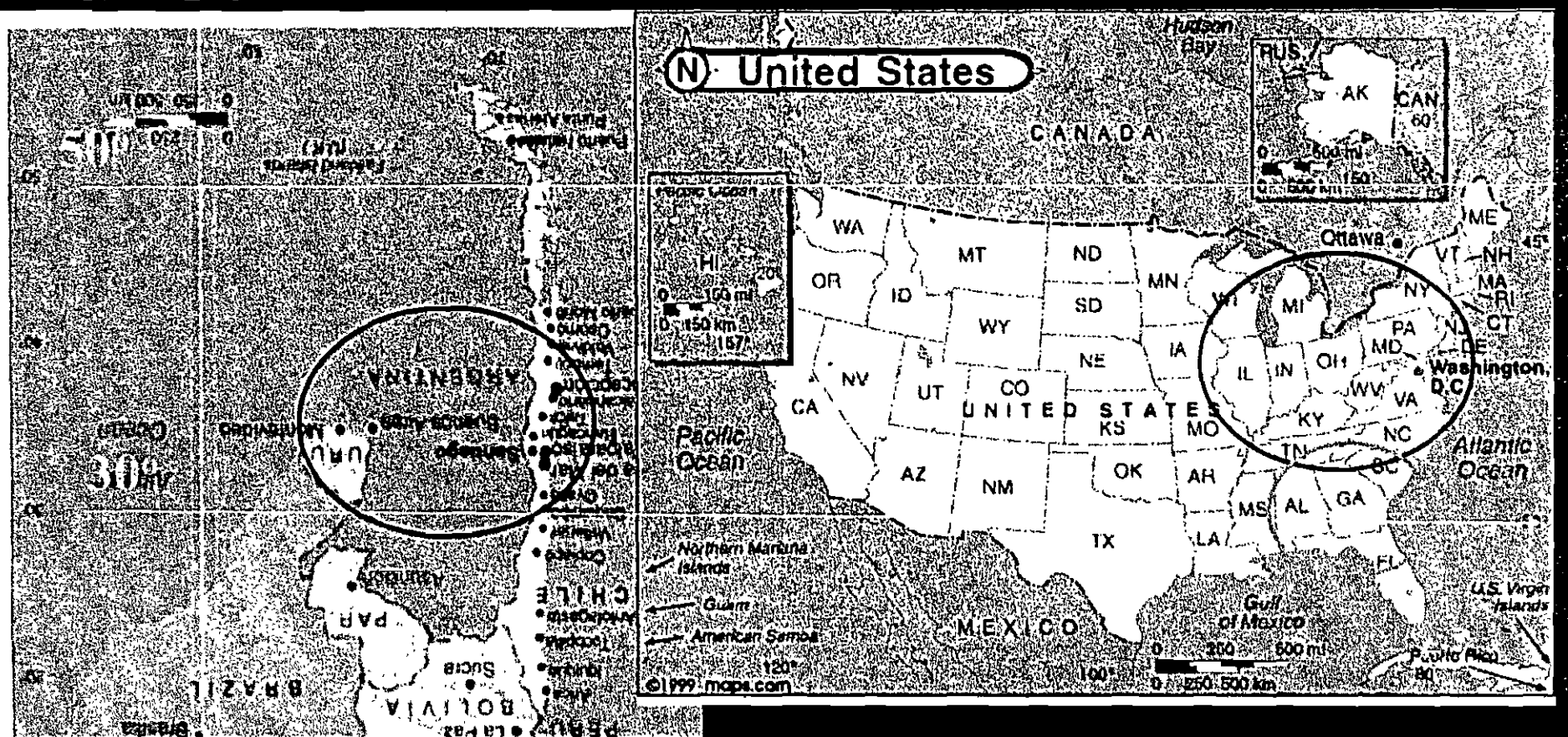
"Blueberry production in South America"

M. Pilar Bañados

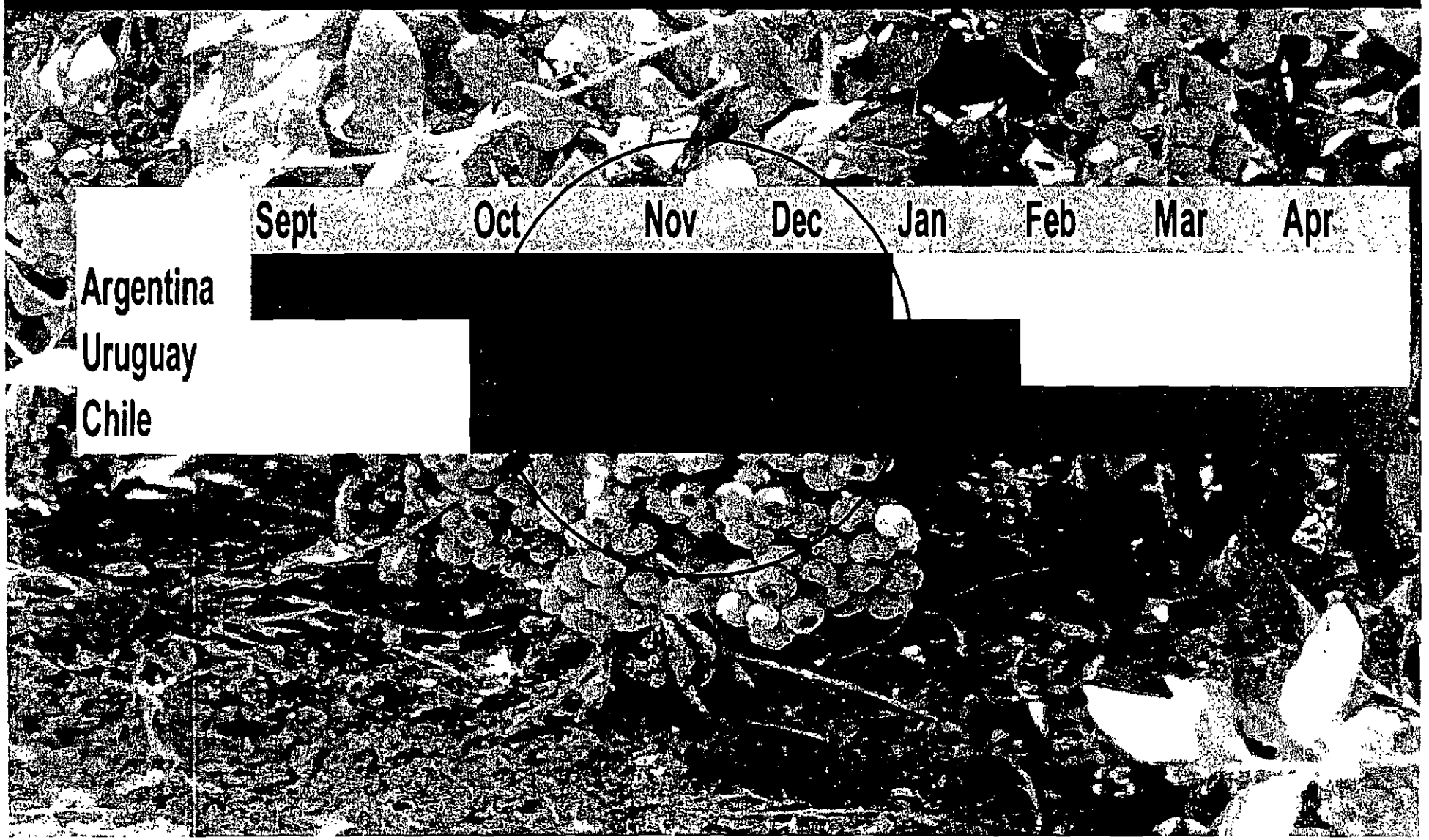
Assistant Professor

Pontificia Universidad Católica de Chile

Compare to Blueberry native area in the US



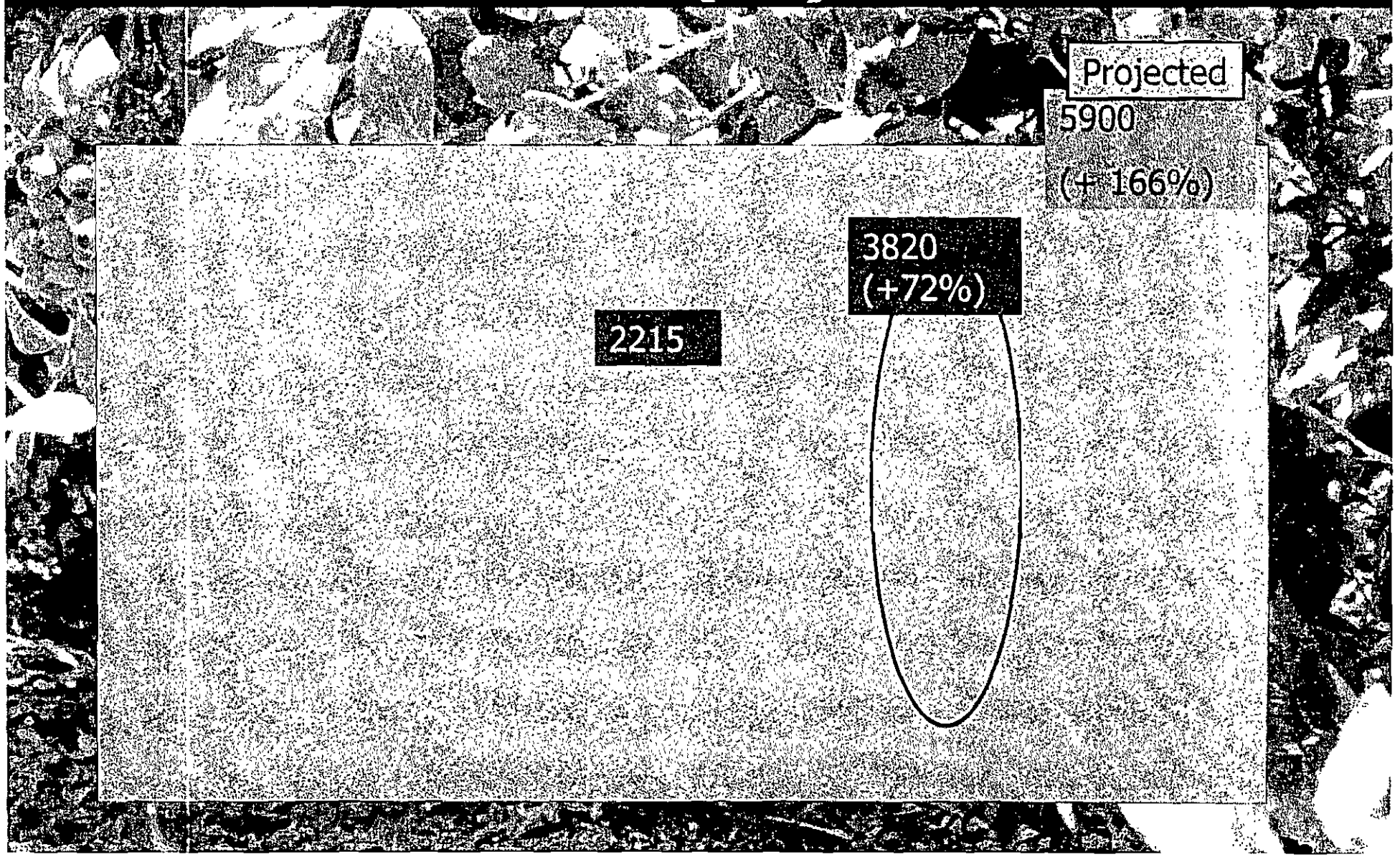
Blueberry season in South America



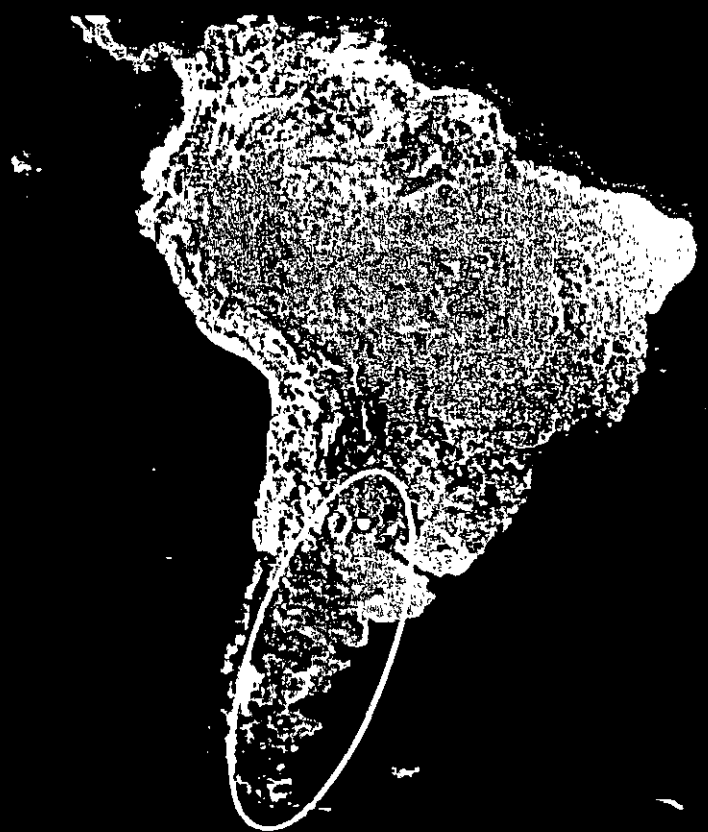
Blueberry in South America 2004

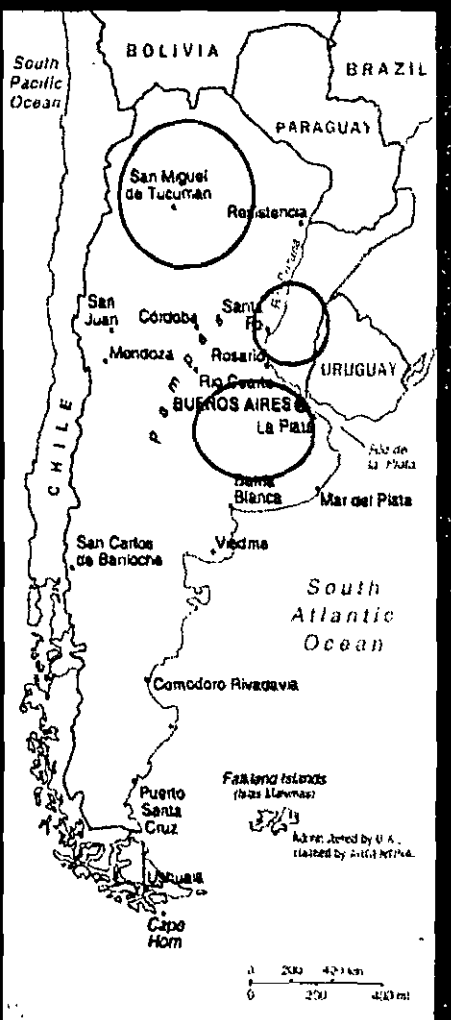
Country	Surface (ha)*	
Argentina	1200	
Brazil	20	
Chile	2500	
Uruguay	100	
TOTAL South America	3820	9.8%
World Highbush BB surface (ha)	38640	100%

Changes in surface over time (ha)



Argentina




South Pacific Ocean
BOLIVIA
BRAZIL
PARAGUAY
San Miguel de Tucuman
Resistencia
San Juan
Córdoba
Santa Fe
Mendoza
Rosario
URUGUAY
Río Cuarto
BUENOS AIRES
La Plata
CHILE
Bahía Blanca
Mar del Plata
San Carlos de Bariloche
Viedma
South Atlantic Ocean
Comodoro Rivadavia
Falkland Islands
(Islas Malvinas)
Puerto Santa Cruz
Ushuaia
Cabo Hom

Blueberry Production

Year	Production (Ton)	% annual increased
1997-98	38	
1998-99	60	58
1999-00	95	58
2000-01	213	124
2001-02	363	70
2002-03	550	52
2003-04	900	64
2004-05	1200	33
2005-06	2000	67
2006-07	2700	35

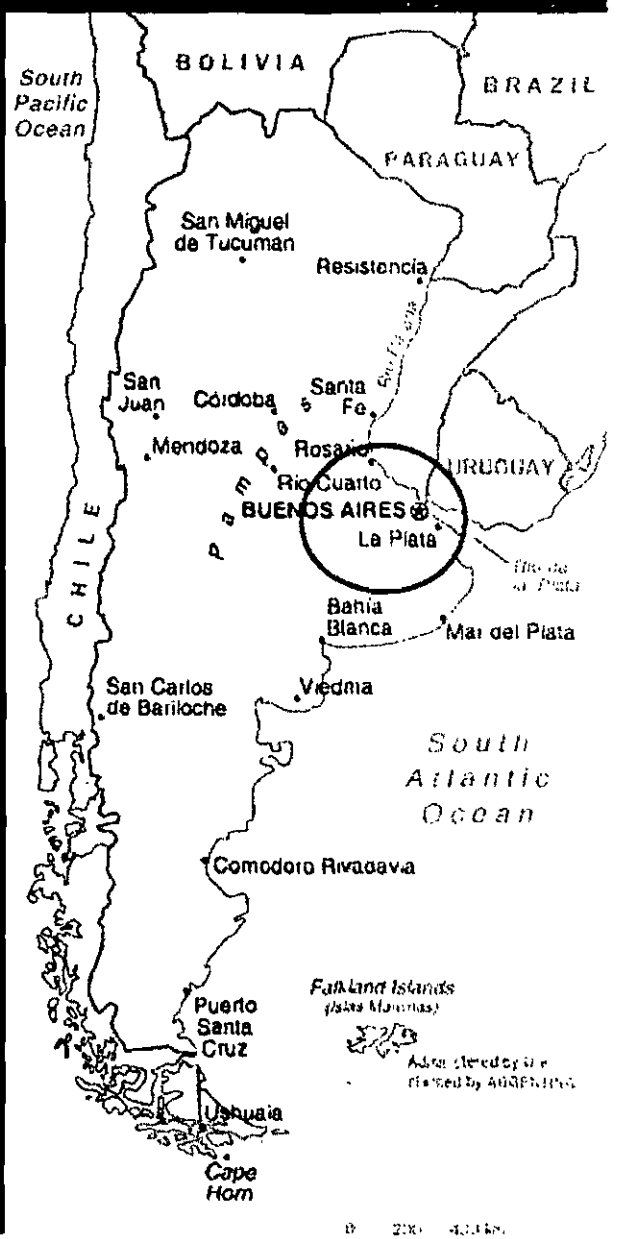
Projected

Source: Technovital, Argentina

North-central Buenos Aires

(34oS)

- First developed area
- Temperate climate, 500 CH, risk of late spring frost
- Mainly orchard of 5-15 ha
- Harvest from Oct 25 to January 15
- Frost and hail protection are required
- Highest technology
- Export companies are located in this area



The Uptake and Use of ^{15}N-Nitrogen in Young and Mature Field-Grown Highbush Blueberries

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Keywords: *Vaccinium corymbosum*, fertilization, growth, partitioning, yield, berry size, planting

Abstract

The effect of nitrogen (N) fertilization rate on growth, yield and N partitioning in young and mature field-grown 'Bluecrop' was studied. Depleted ^{15}N-$(NH_4)_2SO_4$ was applied in the first year (2002) and non-labeled fertilized in the second year (2003). Only first-year results are reported here. Three N fertilizer rates (0, 100 and 200 kg N ha $^{-1}$) and two in-row spacing treatments (0.45m and 1.2m) were studied in the mature planting. Four N fertilizer rates (0, 50, 100 and 150 kg N ha $^{-1}$) were applied in the establishment year of a new planting, spaced at 1.2m. In both studies, the N fertilizer was applied as a triple split (33%:33%:33%) from April through June. Plants were destructively harvested from the field and divided into parts on six dates from February to October 2002. Plant parts were analyzed for dry weight, N and ^{15}N concentration (%) and nitrogen derived from fertilizer (NDFF) calculated. In the mature planting, N fertilization rate had no effect on plant dry weight, but plants at 1.2m were larger than those at 0.45m. Plants fertilized with 200 kg N ha $^{-1}$ had a higher total N content in July and September than unfertilized plants. Percent NDFF increased from 3% in April to 23% in September, with no treatment effect. Fertilizer recovery was initially slow (only 1 to 2% recovery two weeks after the first split), but increased to 22% to 43% in September depending on in-row spacing and N rate; plants spaced at 0.45m recovered a higher percentage of the fertilizer. Yield was not affected by N fertilization rate, but was 35% higher at 0.45m than at 1.2m. In the new planting, established using two-year-old plants, N rate affected plant dry weight, total nitrogen content, percent NDFF, and fertilizer recovery. By October, plants fertilized with 50 kg of N ha $^{-1}$ had the largest dry weight and N accumulation. Ammonium toxicity was observed in plants fertilized with 100 and 150 kg N ha $^{-1}$. Percent NDFF was 60% and 67% for the 50 and 100 kg N ha $^{-1}$, respectively. Fertilizer recovery reached its maximum in October (17% and 10% for the 50 and 100 kg of N ha $^{-1}$).

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 generally been applying recommended rates of nitrogen (N) fertilizer, 110 kg

N ha $^{-1}$ for mature plantings at 1.2m by 3m (Strik and Hart, 1991; Strik et al., 1993) or have been applying much higher rates, depending on their production practices (Martin et al., 2001).

Various studies have been completed on the effect of rate of nitrogen fertilization on the growth and yield of mature blueberry plants. In a study on 'Bluecrop', comparing a nitrogen rate of 75 kg N ha $^{-1}$ to an unfertilized control (no fertilizer for 5 years), plants fertilized with a split application of N had the highest yield (Hanson and Retamales, 1992). Clark et al. (1998) found that yield of 'Collins' was not affected by fertilization rates of 22 and 112 kg N ha $^{-1}$; however, applications of 67 and 134 kg N ha $^{-1}$ reduced yield compared to the 22 kg N ha $^{-1}$ treatment over two years.

Throop and Hanson (1997) showed that mature blueberry plants absorbed fertilizer N most efficiently during active growth between late bloom and fruit maturity; however, only 8% of the fertilizer was recovered two weeks after application. Mature 'Bluecrop' fertilized with 40 kg N ha $^{-1}$ of urea before bud break, recovered 32% of the fertilizer N by the following fall (Retamales and Hanson, 1989). Previous researchers have suggested that multiple applications of fertilizer nitrogen would be necessary to maintain sufficient soil N levels throughout the period of high demand.

No work has been published to date on N fertilizer uptake and partitioning of young blueberry plants.

The objectives of our study were to determine the impact of rate of nitrogen fertilizer application on N uptake, partitioning, growth, and yield of mature blueberry plants at an in-row spacing of 0.45m or 1.2m and of young blueberry plants.

MATERIALS AND METHODS

Mature planting

An existing 'Bluecrop' planting at the North Willamette Research and Extension Center (NWREC), established in October, 1993, was used for this study. 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. Plants were spaced at 0.45m or 1.2m in the row with 3m between rows.

The N fertilizer rate treatments were: 0, 100, or 200 kg N/ha applied as a triple split (33% April 9; 33% May 9; and 33% June 17, 2002); the equivalent rates per plant were 0, 14, and 28 g · plant $^{-1}$ at 0.45m and 0, 37, and 74 g · plant $^{-1}$ at 1.2m. ^{15}N-depleted ammonium sulfate [$(NH_4)_2SO_4$] fertilizer was used. All treatment plots were fertilized with 35 kg·ha^{-1} of P and 66 kg·ha^{-1} of K each spring. The treatments were arranged in a randomized complete block design with 3 replicates.

One plant per plot was destructively harvested on each of 5 dates from spring to fall 2002. Plants were dug to ensure recovery of as much of the root system as possible. Roots were washed. Plants were separated into their parts: current season growth, 1-year-old, 2-year-old and older wood, crown, roots, leaves, floral buds, vegetative buds, flowers, fruit and senescing leaves depending on the stage of development. Each part was dried and dry weight measured and then sub-samples were ground and total N, and ^{15}N concentration measured.

Plots were harvested by an over-the-row rotary machine harvester (Littau Harvesters Inc., Stayton, Ore., USA) in 2002. Data collected included yield and average berry weight (25 berries per harvest).

Young planting

A planting of 'Bluecrop' was established at the NWREC on March 27, 2002. Sawdust and fertilizer (66 kg·ha^{-1} of N) were incorporated prior to planting two-year-old container stock. No surface sawdust mulch was applied. Blossom buds were pruned off the plants at planting. Plants were spaced at 1.2m in the row with 3m between rows.

The treatments were four different nitrogen (N) rates: 0, 18.6, 37.2, or 55.8 g · plant $^{-1}$ (equivalent to 0, 50, 100, or 150 kg N ha $^{-1}$, respectively). The N fertilizer was applied as a triple split (33% April 11, 33% May 20, and 33% June 27). ^{15}N-depleted ammonium sulfate [$(NH_4)_2SO_4$] fertilizer was used. All treatment plots were fertilized with 35 kg·ha^{-1} of P and 66 kg·ha^{-1} of K each spring. The treatments were arranged in a randomized complete block design with 3 replicates.

Plant growth, dry weight, N, and ^{15}N partitioning data were collected as mentioned for the mature planting.

Soil samples were collected on each plant sampling date and pH determined.

RESULTS AND DISCUSSION

Mature planting

Total plant dry weight was significantly affected by in-row spacing, but not by N fertilization rate. Thus, the data in figure 1 are averaged over N fertilizer rate. Plants spaced at 1.2m were larger than those spaced at 0.45m (Figure 1). Dry weight increased over time at both in-row spacing treatments; the dry weight data for October were taken before plants were pruned. The percentage of dry weight allocated to roots was 27% and 25% for plants spaced at 0.45m and 1.2m, respectively in September. Proportion of dry mass partitioned to roots in September was not related to rate of N fertilization (data not shown). The crown and roots accounted for 43% to 52% of total plant biomass, similar to the amount reported by Retamales and Hanson (1989).

Plant nitrogen content increased throughout the season, with the largest accumulation at the end of the season in September. Plants spaced at 1.2m accumulated more N (27 g · plant $^{-1}$ on Sept. 11) than those at 0.45m (15 g · plant $^{-1}$), due to their larger size. Nitrogen fertilization rate had a significant effect on total plant N content on July and September ($P <$ 0.05; Figure 2). The concentration of N (%N) was affected by N fertilization rate, especially in young tissues (shoots, fruit, and 1-year-old wood), thus affecting the total N content in the plant (data not shown).

Fertilizer N was not taken up very quickly at either spacing (Figure 3). Two weeks after the first split of fertilizer N was applied, plants had recovered only 1 to 2% of the applied fertilizer; this recovery is similar to the 1% fertilizer recovered two weeks after an application before bud break reported by Throop and Hanson (1997). In our study, fertilizer recovery increased to 4 % in May (two of the three splits applied), 12 to 17% in July (two weeks after last split applied), and 22 to 43% in September, at the end of the season. The amount of fertilizer N in plants was at a maximum for the season in September (our last plant

harvest date in the season of application); thus our results differ from those of Retamales and Hanson (1989) who found that fertilizer N content in plants peaked three weeks after a single application of labeled urea before bud break. Perhaps in our milder climate the period of most rapid growth is later than in Michigan or shoots grow for a longer period of time. Percent NDFF increased from 3% in April to 23% in September, with no treatment effect.

Plants spaced at 0.45m and fertilized with 100 or 200 $kg \cdot ha^{-1}$ of N took up 43% or 31% of the fertilizer including harvested fruit, respectively, by September. At the 1.2m in-row spacing, plants recovered 23% of the fertilizer N at the 100 or 200 $kg \cdot ha^{-1}$ of N rate. Our recovery rates are similar to the 32% reported for mature blueberry (Retamales and Hanson, 1989). In September, leaves accounted for 34 to 46% of the total fertilizer N in the plant, similar to the 32% reported by Retamales and Hanson (1989).

The higher fertilizer uptake at the 200 kg N/ha rate may have been "luxury" uptake. The N concentration of the leaves of unfertilized plants averaged 0.57 %N at senescence (Nov. 11) whereas the leaves of fertilized plants averaged 0.76 and 1.0 %N at 100 or 200 $kg \cdot ha^{-1}$ of N, respectively; the percent of total N in the leaves that came from the fertilizer averaged 41% and 49% at 100 or 200 $kg \cdot ha^{-1}$ of N, respectively. Thus, a considerable amount of fertilizer N (from 3 to 10 $kg \cdot ha^{-1}$ of N) was "lost" at leaf senescence – this would, however, be returned to the soil pool of N.

Total N harvested in the fruit averaged 12 and 9 $kg \cdot ha^{-1}$ for the 0.45m and 1.2m spacing, respectively. The percentage of N derived from the fertilizer (NDFF) in the harvested fruit was 28% for the 100 $kg \cdot ha^{-1}$ of N treatment at either in-row spacing. However, plants fertilized with 200 $kg \cdot ha^{-1}$ of N had 42% NDFF in fruit at the 0.45m spacing and 35% NDFF at 1.2m. Thus, the amount of fertilizer N harvested in the fruit ranged from 2 to 6 $kg \cdot ha^{-1}$ (data not shown).

In-row spacing had no significant effect on N concentration of fruit. However, N fertilization significantly increased N concentration of harvested fruit: Fruit from unfertilized plants averaged 0.63 %N whereas fruit from fertilized plants averaged 0.84 and 0.92 %N when fertilized with 100 or 200 $kg \cdot ha^{-1}$ of N, respectively. Thus higher rates of N fertilization can increase N content of fruit, despite relatively little fertilizer being taken up before the fruiting season; it is not known how this would impact fruit quality.

Yield and berry weight in 2002, the first year N fertilization treatments were imposed were not affected by N fertilization rate, only by in-row spacing. Unfertilized mature 'Bluecrop' plants in Michigan did not have reduced yield, compared to those fertilized with 75 $kg \cdot ha^{-1}$ of N until year three (Hanson and Retamales, 1992). The high-density planting (0.45m) had 35% more yield per hectare than the 1.2m spacing, 14 t/ha compared to 10 t/ha (averaged over fertilization rate). We have documented higher yields of mature, high density 'Bluecrop' plantings in the past (Strik and Buller, 2002).

Young planting

The pH of the potting soil of the plants used in this study was 4.3. The initial pH of the field before planting and treatments were imposed was 4.9 (March 2002). Fertilization with ammonium sulfate decreased the soil pH during this study to 4.0 in October compared to 5.1 for the un-fertilized treatment.

Nitrogen fertilization rate affected plant growth (dry weight) over time (Figure 4). Differences among treatments were observed as early as June, when total plant dry weight was reduced in plants that received 0 or 150 kg·ha^{-1} of N compared to those that received 50 or 100 kg·ha^{-1} of N. By the end of the first growing season, plants fertilized with 50 kg·ha^{-1} of N had the largest accumulation of dry weight (Figure 4). Plants fertilized with 100 and 150 kg·ha^{-1} of N showed severe signs of NH_4 toxicity, with 17% and 55% of the plants dying by October, respectively. In July, plants showing symptoms of toxicity had very high levels of NH_4 in their shoots compared to the other treatments (data not shown).

The top-to-root ratio was 1.2, 1.6, 2.1, and 1.5 for the 0, 50, 100, and 150 kg·ha^{-1} of N treatments in October, respectively. Unfertilized plants had a lower dry weight of leaves and shoots than those fertilized with 50 kg·ha^{-1} of N. Plants fertilized with 150 kg·ha^{-1} of N had a lower total plant dry weight as a result of less weight in all plant parts.

At planting time, the initial total plant nitrogen content was 335 mg per plant. Total N increased during the first growing season, and was affected by N fertilization rate (data not shown). Plants that received 50 or 100 kg·ha^{-1} of N accumulated 4550 mg and 4025 mg of N per plant, respectively. Plants that were not fertilized with N accumulated only 1894 mg of N per plant. Plants fertilized with 150 kg·ha^{-1} of N accumulated 2318 mg of N per plant.

Leaf N concentration for the N fertilization treatments on July 24 was 1.4%, 2.8%, 2.8%, and 3.8% for the 0, 50, 100, and 150 kg·ha^{-1} of N treatments, respectively. Thus, plants that were not fertilized were deficient in N in late July; plants fertilized with 50 and 100 kg·ha^{-1} of N had normal leaf N concentrations, and the leaves from plants fertilized with 150 kg·ha^{-1} of N had a high N concentration due to poor shoot growth (Strik and Hart, 1991).

There was very little uptake of fertilizer N two weeks after the first application (Figure 5). Less than 1% of the fertilizer applied was recovered by plants at the end of April. The content of N derived from the fertilizer increased in the plants through October (Figure 5); this was also the time of greatest percent NDFF. The highest percentage of fertilizer recovery occurred in plants fertilized with 50 kg·ha^{-1} of N (17% in October). Plants fertilized with 100 kg·ha^{-1} of N recovered 10% of the fertilizer applied by October. Even though plants took up only 9 to 10 kg·ha^{-1} of N, this fertilizer N accounted for 60% to 67% of the total N in the plant (data not shown). Thus young blueberry plants do not require much fertilizer N in the planting year.

There was a large treatment effect on N concentration in the leaves at senescence. In un-fertilized plants, leaves senesced with a low concentration of N (0.5 % N), compared to 2.4 to 3.7 % N in the fertilized treatments. Thus un-fertilized plants appear to have re-mobilized N from leaves to storage tissues (~ 6 kg·ha^{-1} of N). In the fertilized treatments, 46% to 51% of the fertilizer N in the plant in October was present in the leaves. Plants that were fertilized with N also had a higher concentration of P, K, Ca, Mg, Mn, and C in leaves at senescence (data not shown).

CONCLUSIONS

There was no effect of N rate on yield or berry weight in the first season on this study; however an effect would be expected in subsequent years. Fertilizer recovery by plants was initially slow and did not peak during the season – rather, recovery was highest in the fall. This indicates that plants were able to take up the fertilizer N more than three months after

application. Thus, fertilizer N was still present in the soil (a clay loam) and had not totally been leached out of the rooting zone (soil N data are not presented here). Our data support the advantage of providing N fertilizer to plants in a split application to maintain N levels throughout the period of high demand.

When we calculated net fertilizer recovery (^{15}N recovered by plants minus the ^{15}N fertilizer present in harvested fruit and leaves at senescence), plants spaced at 0.45m had a higher net recovery (24% to 33% when fertilized with 200 or 100 $kg \cdot ha^{-1}$ of N, respectively) than those spaced at 1.2m (17% regardless of N rate). Thus, plants at a higher density seem more efficient at taking up fertilizer N than those at a wider spacing implying that recommended N fertilizer application rates should not be proportional to planting density as has been done in the past (Strik and Hart, 1991).

Young plants were much more sensitive to under- and over-fertilization in our study than the mature plants because they did not have a lot of stored N reserves to serve as a "buffer" and the young root system was very sensitive to fertilizer "burn". In new plantings, N fertilizer should likely be applied in several split applications, at a low rate, to meet N demand yet minimize risk of harming young plants.

ACKNOWLEDGEMENTS

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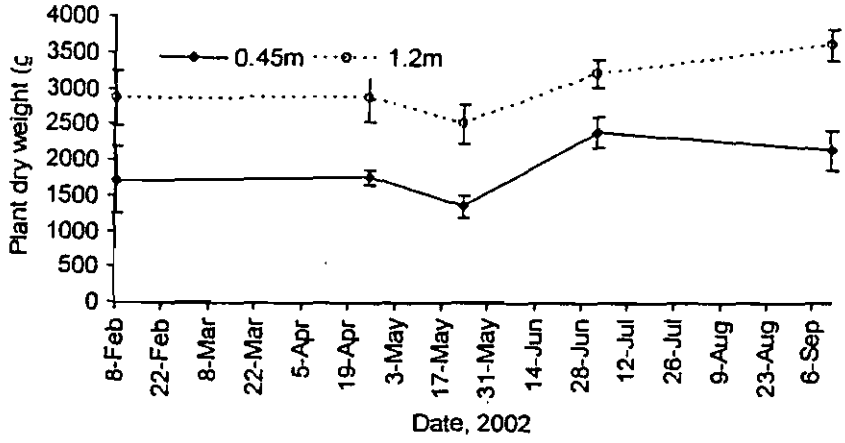

Figure 1. Plant dry weight of mature 'Bluecrop' plants at an in-row spacing of 0.45m or 1.2m in 2002, averaged over nitrogen fertilization rate. Mean ± SE.

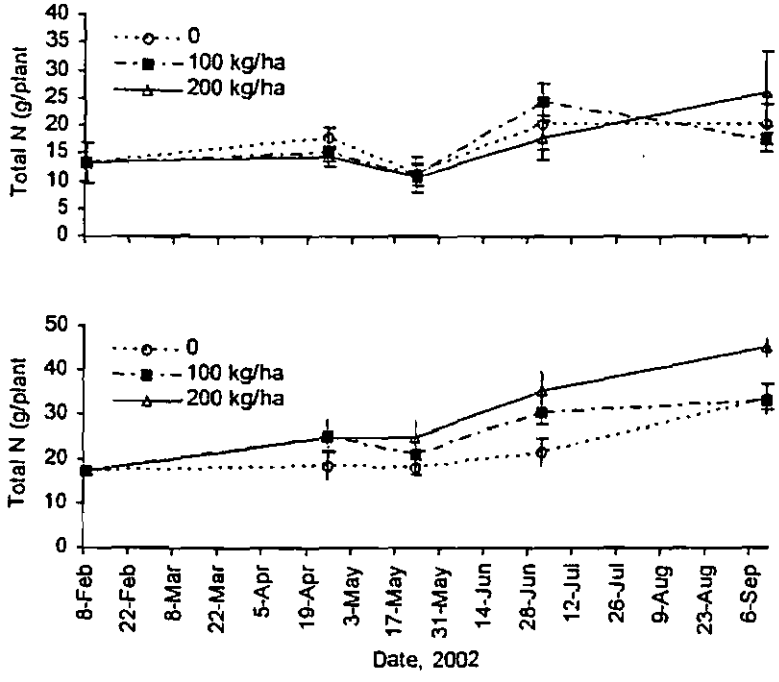

Figure 2. The effect of nitrogen fertilization rate at two in-row spacings A. 0.45m and B. 1.2m on total N content of mature 'Bluecrop' in 2002. Mean ± SE

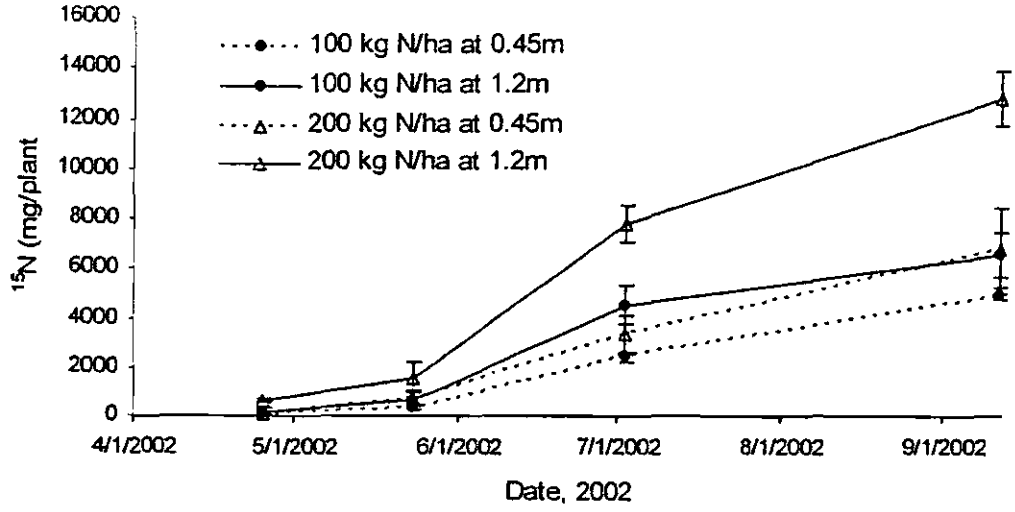

Figure 3. The effect of nitrogen fertilization rate at two in-row spacings on total N content from the fertilizer in mature 'Bluecrop' in 2002. Mean ± SE

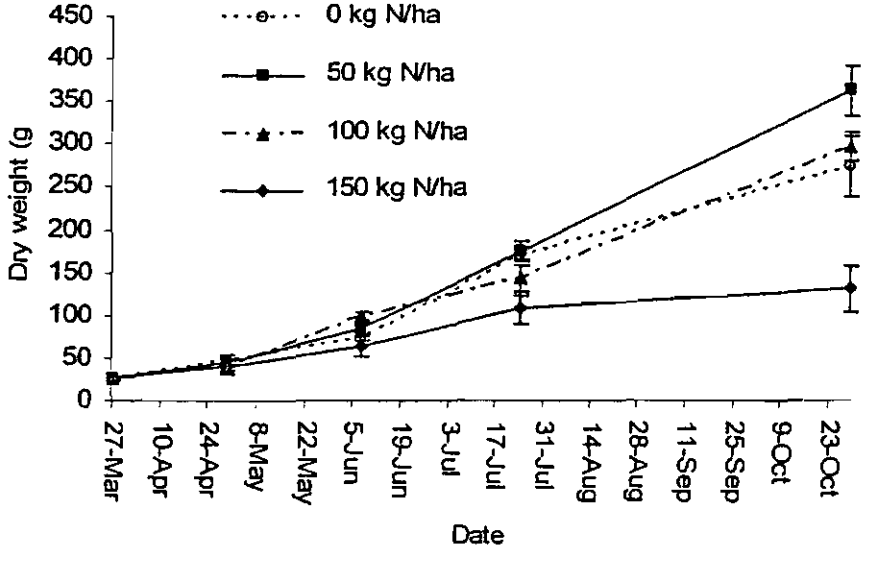

Figure 4. Plant dry weight of 'Bluecrop' in the establishment year (2002) as affected by N fertilization rate.

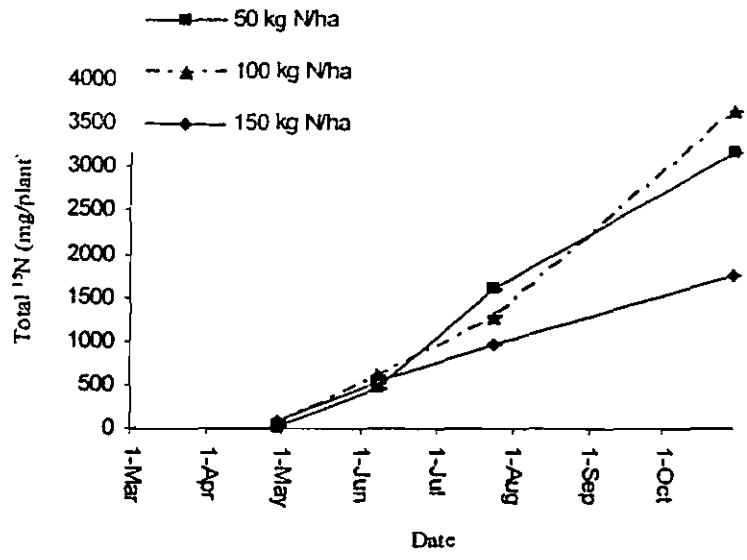

Figure 5. The effect of nitrogen fertilization rate on total N content from the fertilizer of 'Bluecrop' in the establishment year, 2002. Mean ± SE

Blueberry Production and pH Modification

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February 14, 2003

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Blueberry production is possible in many soils if proper soil and water modifications are among the high priority of factors to resolve from the onset. Blueberries are a unique crop in that the plants require acidic conditions. The blueberry is a member of the Heather family. It is closely related to azaleas, rhododendrons, and cranberries. Blueberries require a soil pH of 4.5 to 5.5 for good growth and optimum fruit production. Soils higher than pH 5.8 can cause iron chlorosis and reduced blueberry plant growth and yield. There are two components of pH modification when evaluating blueberry production: soil and water pH.

Definition of pH

Almost all agricultural crops prefer a soil pH near neutral, generally in the range of 6 to 8. Blueberry production is an exception.

The pH scale runs from 0 to 14. 0 is acidic, and 14 is basic or alkaline. A pH of 7 is neutral. The terms *acid, neutral and alkaline or basic* refer to the relative concentration of hydrogen ions (H^+) and hydroxyl ions (OH^-) in the soil or water solution. An acid soil or water has a higher concentration of hydrogen ions than hydroxyl ions, while an alkaline soil or water has the opposite. A neutral pH means the hydrogen ions and the hydroxyl ions are present in equal amounts and counteract the effect of one another.

Since pH is a logarithmic function, each pH unit represents a tenfold increase or decrease in relative acidity or alkalinity. For example, a soil or water with a pH of 6.0 is 10 times as acidic as one with a pH of 7.0. A soil or water with a pH of 8.0 is 10 times as alkaline as one with a pH of 7.0 and 100 times as alkaline as one with a pH of 6.0.

Table 2 Changing soil pH with sulfuric acid

	Desired pH Value														
	4.0			4.5			5.0			5.5			6.0		
Present pH of soil	Sand	Loam	Clay	Sand	Loam	Clay	Sand	Loam	Clay	Sand	Loam	Clay	Sand	Loam	Clay
	Tons of Sulfuric Acid per Acre														
5.0	.52	1.57	1.70	.26	.79	.92	0.0	0.0	0.0						
5.5	.78	2.29	2.42	.52	1.57	1.70	.26	.79	.92	0.0	0.0	0.0			
6.0	.98	3.01	3.14	.79	2.29	2.42	.52	1.57	1.70	.26	.79	.92	0.0	0.0	0.0
6.5	1.24	3.79	3.92	.98	3.01	3.14	.79	2.29	2.42	.52	1.64	1.70	.26	.78	.92
7.0	1.50	4.51	4.64	1.24	3.79	3.94	.98	3.00	3.14	.79	2.29	2.42	.52	1.57	1.70
7.5	1.77	5.23	5.36	1.50	4.51	4.64	1.24	3.79	3.92	.98	3.00	3.14	.78	2.29	2.42

Table 2 is a conversion of the data in table 1. Sulfuric acid to sulfur is assumed to be a 3:1 ratio. Both sulfuric acid and sulfur are assumed to be 100%. However, products currently available for agricultural soil amendments are typically 95% sulfur and 93% sulfuric acid.

An important variable not taken into account in the tables is the free lime, or calcium carbonate content of the soils. The greater the free lime content of the soil, the more soil amendment will be required to bring about a reduction in pH. Free lime is a buffer, which resists pH changes in the soil.

Soil sulfur can be used to lower the pH of soils. Divide the values in table 2 by three to obtain the equilivant value. The larger the sulfur particle, the less surface area is exposed to the soil and it will take longer to bring about a change in the soil. Sulfuric acid will bring about a change of pH quicker than soil sulfur.

Gypsum (calcium sulfate) is a neutral salt. Except under specific extreme conditions, gypsum will not lower the soil pH or reduce the calcium carbonate content of the soil.

A preplant soil test is also valuable in measuring the levels of other important nutrients such as phosphorus, potassium, calcium, and magnesium. Improving the levels of these nutrients in the soil is done most effectively if they are incorporated before planting.

Acidification of Irrigation Water[2]

If a grower is considering lowering the pH to 5.0 or below, the grower should consult the irrigation manufacturer, to be sure the materials of construction are suitable for the pH range being considered. The primary material where damage will happen very quickly if the pH becomes too low is nylon.

The on site acid storage tanks are extra heavy wall polyethylene. Normal tanks are manufactured to contain up to 12.5 pound per gallon liquids. Since sulfuric acid weights 15.3 pounds per gallon, 16 pound per gallon rated storage tanks are required. The tanks may be set on level ground, on a decomposed granite base, or on a concrete slab. Preferably there will be a slight slope to the base, so the residual material in the tank will accumulate at the outlet.

The field storage tanks typically have a two inch fill fitting on the top of the tank. We have found that having the fitting on top reduces the exposure by vandalism and leaking gaskets. A 3/4 inch fitting is installed at the bottom. This is for the supply line, which goes to the acid injection pump.

Growers need to evaluate the security of the site, since acids are hazardous materials. If there is a reasonable chance of vandalism, a chain link fence should be installed around the acid storage and possibly the filter station as well. Double wall containment is also an option.

The sulfuric acid injection systems are suitable for urea-sulfuric acid fertilizers and phosphoric acid. However, if changing material is desired, the system needs to be cleaned out by our service personnel first. The grower should not attempt to mix other products going through the acid injection pump. Either there is a heat reaction or the irrigation system downstream has plugged up. If other fertilizers are to be injected, a separate stand-alone system is required. It is ok to inject solution grade gypsum at the same time as sulfuric acid.

Secondary backup safeguard systems should be installed in the acid injection system. It is critical that water does not back up into the sulfuric acid storage tank. If this were to happen, an exothermic heat reaction would occur and the plastic tank would melt down. It is important to remember - always add an acid to water, never add water to an acid.

Growers should work with a reliable supplier to install and maintain the sulfuric acid injection equipment. Growers should ask if the supplier has the capability of vacuuming out the field storage tank in the event of a leak. Safety to the irrigation equipment and to individuals should also be considered, because sulfuric acid is a hazardous material. If growers are able to minimize the exposure, while improving the irrigation water quality at a price that is economically feasible, then they should consider amending the irrigation water.

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[1] Midwest Small Fruit Pest Management Handbook, Bulletin 680

[2] Gregory, James R., "Uses of Sulfuric Acid as a Water Amendment in Agriculture," Proceedings, International Irrigation Show, The Irrigation Association, San Antonio, Texas, November 4, 2001

Blueberry Studies

Kearney Agricultural Center, 2003

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Plant Size Trial

For the plant size evaluation study we compared 2" cell, RP5, 3 ½" pot, 1 Liter, 1 gallon and bare root plants. The purpose of is to save the growers money by purchasing smaller plants. For example in an acre with 3 foot plant spacing (1300 plants) a 1gallon plant would cost $2.80 compared to a 2" cell at $1.80. On an acre plot this would save $1,300. The 2" cell, RP5, 3 ½" pot and bare root were planted in the field after a year in the green house and the 1 liter and 1 gallon plants were planted in the field after two years in the green house. All plants were planted in the field during October 2001.

Table 1. Plant Size Evaluation- O'Neal
Pounds per Plot

1 gal.	7.69	a
1 L	5.37	a
2" cell	0	b
3 1/2" pot	0	b
Bare root	0	b
RP 5	0	b
CV		98.18
LSD		3.22

Table 2. Plant Size Evaluation- O'Neal
Pounds per Acre

1 gal.	1450	a
1 L	1013	a
2" cell	0	b
3 1/2" pot	0	b
Bare root	0	b
RP 5	0	b
CV		98.18
LSD		607

The 2" cell, 3 ½" pot, bare root and RP5 had no yield the first year because there was no bloom or they were too small for us to allow them to produce a crop. One interesting thing that has surfaced from the study in the difference between the varieties O'Neal and Misty within the same trial. On O'Neal there was no significant difference between the gallon and liter plants whereas on Misty the gallon plants produced about two times as much as the liter plant. Also the 1 gallon Misty plants yielded about three times as much as the 1 gallon O'Neal plants did. The varieties O'Neal and Misty were picked because they are the ones most growers are planting. O'Neal is one of the earliest varieties and Misty one of the most common because it is easy to grow and very vigorous.

Table 3. Plant Size Evaluation- Misty
Pounds per Plot

1 gal.	25.65	a
1 L	11.70	b
2" cell	0	c
3 1/2" pot	0	c
Bare root	0	c
RP 5	0	c
CV		54.41
LSD		4.17

Table 4. Plant Size Evaluation- Misty
Pounds per Acre

1 gal.	4840	a
1 L	2207	b
2" cell	0	c
3 1/2" pot	0	c
Bare root	0	c
RP 5	0	c
CV		54.41
LSD		786

Plant Spacing Trial

The plant spacing trial was designed to evaluate spacing from 18-48 inches at 6 inch increments. Plant populations ranges from 990 at 48" to 2,640 at the 18" spacing. The purpose of the study is to increase yield per acre. One pro of increasing plant spacing is that fixed costs will remain the same regardless of the number of plants on an acre the amount of mulch and water will not change. Some cons are that the variable costs will increase. Pruning and harvest costs will go up with plant population. The cost of purchasing the extra plants will also increase expenditures.

Table 5. Plant Spacing- O'Neal, lbs/plot

24"	13.60	a
8"	12.76	ab
30"	10.43	ab
36"	8.44	ab
42"	7.48	ab
48"	5.98	b
CV		46.85
LSD		6.91

Table 6. Plant Spacing- O'Neal, lbs/acre

24"	2567	a
18"	2408	ab
30"	1967	ab
36"	1592	ab
42"	1411	ab
48"	1127	b
CV		46.85
LSD		1303

The plant spacing study shows significant yield contrast between the Misty and O'Neal varieties. The highest yielding Misty (18") was three times higher than the highest yielding O'Neal (24"). Even the lowest yielding Misty (48") was still higher than the highest yielding O'Neal. Also the Misty plants were more consistent; there was a perfect linear increase in yield with increase in plant population. O'Neal has been very inconsistent and hasn't preformed as expected, with the 24" spacing actually yielding a little more than the 18" spacing.

Table 7. Plant Spacing- Misty, Lbs/Plot

18"	40.60	a
24"	34.58	ab
30"	30.18	bc
36"	26.80	cd
42"	21.29	de
48"	17.35	e
CV		16.10
LSD		6.91

Table 8. Plant Spacing- Misty, lbs/Acre

18"	7660	a
24"	6524	ab
30"	5694	bc
36"	5056	cd
42"	4016	de
48"	3274	e
CV		16.10
LSD		1303

Replicated Variety Trial

Since 1997 we've planted 40 varieties of blueberries. From the 40 varieties eight Southern High Bush varieties were selected for this trial. Within the eight varieties four are early varieties, and the other four are mid season varieties. The early varieties include O'Neal, Sharp Blue, Misty and Star. The mid season varieties are Ozark Blue, Jubilee, Southmoon and Legacy. For this trial we are testing for yield and fresh market quality indices and plan to evaluate shelf life of each variety in 2004.

Table 9. Replicated Variety Trial, lbs/plot

Legacy	38.63	a
Jubilee	34.66	ab
Star	32.01	b
South Moon	24.92	c
Misty	23.60	c
Sharp Blue	22.89	c
Ozark Blue	12.43	d
O'Neal	8.85	d
CV		17.93
LSD		6.53

Table 10. Replicated Variety Trial, lbs/acre

Legacy	7289	a
Jubilee	6540	ab
Star	6039	b
South Moon	4701	c
Misty	4453	c
Sharp Blue	4319	c
Ozark Blue	2346	d
O'Neal	1669	d
CV		17.93
LSD		1232

The highest yielding early variety was Star, and the highest yielding mid season variety was Legacy. There is a wide range between the highest and lowest yielding varieties as seen in Tables 9 and 10.

Mulch Study

Blueberries are usually grown with wood mulch culture, but wood mulch is very expensive and may not always be available. We are evaluating two types of wood alternatives which are available and cost less. We used the variety Star. Wood mulches included pine and almond shells. The alternatives included black plastic, white plastic, a herbicide treatment and an untreated check.

Table 11. Mulch Study 2001, lbs/plot

White Plastic	38.30	a
Black Plastic	35.06	ab
Untreated Check	30.19	abc
Pine Mulch	28.18	bc
Almond Shells	26.90	bc
Herbicide	24.29	c
CV		18.44
LSD		8.48

Table 12. Mulch Study 2001, lbs/acre

White Plastic	7226	a
Black Plastic	6616	ab
Untreated Check	5695	abc
Pine Mulch	5316	bc
Almond Shells	5075	bc
Herbicide	4583	c
CV		18.44
LSD		1600

The plastic and untreated check surprisingly had higher yields that the wood mulches. This may have occurred because the bacteria may have consumed the Nitrogen to breakdown the wood whereas all the nitrogen was entirely available to the white and black plastic treatments as well as the untreated check. It is anticipated that during the next few years the wood mulch treatments will develop greater fertility, porosity for good water infiltration and develop greater plant vigor. We expect the other plants to decline as they get older, which is what we have seen in previous mulch studies.

Blossom Removal Study

In this study we are comparing the removal of the blossoms and how it affects plant vigor and yield over the life of the plant. For treatment one we removed the fruit at year one, and for the other treatment we removed the blossoms at year one and two.

Table 13. Blossom Removal Study, lbs/plot

Removed at...		
Year 1	18.10	a
Year 1&2	0	b
CV		20.74
LSD		5.97

Table 14. Blossom Removal Study, lbs/acre

Removed at...		
Year 1	3414	a
Year 1&2	0	b
CV		20.74
LSD		1126

Tables 15 and 16 show that there is no yield for the year one and two treatment because we took the blossoms off. We do expect a higher yield next year due to greater plant vigor.

Pruning Study

Table 15. Pruning Study, lbs/plot

July, 2003	23.6	ns
No Pruning	23.2	ns
Sept. 2002, 2003	21.0	ns
CV		17.18
LSD		7.76

Table 16. Pruning Study, lbs/acre

July, 2003	4447	ns
No Pruning	4380	ns
Sept. 2002, 2003	3967	ns
CV		17.18
LSD		1464

The pruning study is evaluating the effect of tipping, removing the fruiting wood at different times of the year. We have found that there is no significance so far, but believe that tipping might help the plants develop stronger, thicker canes and make it easier to pick.

Irrigation Study

Table 17. Irrigation- O'Neal Rep. Trial Lbs/plot

Single hose: 2L volume	11.57	ns
Double hose: 2L volume	8.85	ns
Single hose: 1L volume	8.63	ns
Double hose: 1L volume	8.89	ns
CV	32.41	
LSD	5.83	

Table 18. Irrigation- O'Neal Rep. Trial Lbs/acre

Single hose: 2L volume	2182	ns
Double hose: 2L volume	1669	ns
Single hose: 1L volume	1628	ns
Double hose: 1L volume	1677	ns
CV	32.41	
LSD	1100	

There is little to no information on appropriate irrigation for blueberries in California. Our study was designed to provide information that will eventually help growers with improved irrigation practices. The treatments include a single hose with 2 liter volume,

double hose with 2 liter volume, single hose with 1 liter volume and double hose with 1 liter volume.

Table 19. Irrigation- W.Half with Misters

Single hose: 2L volume	8.69	ns
Double hose: 2L volume	10.27	ns
Single hose: 1L volume	8	ns
Double hose: 1L volume	10.02	ns
CV	30.15	
LSD	5.25	

Table 19. Irrigation- W.Half with Misters

Single hose: 2L volume	1639	ns
Double hose: 2L volume	1937	ns
Single hose: 1L volume	1509	ns
Double hose: 1L volume	1924	ns
CV	30.15	
LSD	990	

The impact of early cropping on subsequent yield of highbush blueberry

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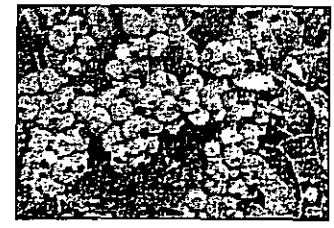
Abstract

The effect of early cropping (no blossom removal the first two years) and in-row spacing at 0.45m and 1.2m 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 1.2m 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 weights 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.



Methods

- Established at the North Willamette Research & Extension Center, Aurora, Ore. in October, 1999 with two-year-old potted plants
- Pre-plant fumigated, sawdust incorporated, and raised beds formed
- Treatments: cultivar (Duke, Bluecrop, Elliott), in-row spacing (0.45, 1.2m); and early cropping ("control" plants had no crop in years 1 and 2; "early cropped" had crop in years 1 and 2). Control plants had blossom buds pruned off in winter 1999/00 and 2000/01
- Yield and other data collected in years 1 through 4 (2000-2003)
- Plots were 6m long with 5 replicates arranged in a RCBD

Results (Figures 1 to 3)

Cropping in years 1 and 2 reduced plant dry weight compared to control plants. 'Bluecrop' had more than double the top root ratio of 'Elliott' (2.5 vs. 1.1, respectively)

Figure 1 Plants dug February 2002. Early cropped on left; control on right

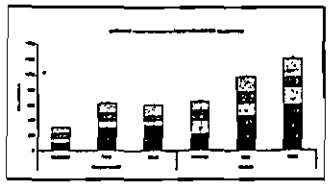


Figure 2 Dry weight of plant parts on Feb. 2002, after one year of early cropping compared to control plants. Averaged over in-row spacing (non significant).

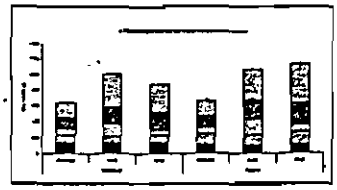


Figure 3 Dry weight of plant parts on Feb 2003, after two years of early cropping compared to control plants. Averaged over in-row spacing (non significant).

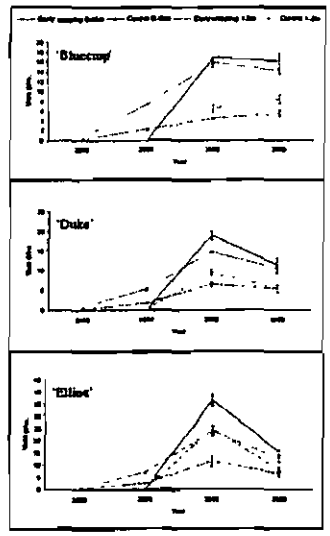


Figure 4 The effect of early cropping and in-row spacing on yield (t/ha) of 'Bluecrop', 'Duke', and 'Elliott' from 2000 – 2003 (planted in October, 1999; mean ± SE)

Results (Figure 4)

- Yield for all cultivars was < 0.7 t·ha^{-1} in year 1 (2000)
- Yield in 2001, for early cropped plants ranged from 2 to 7 t·ha^{-1} depending on cultivar and in-row spacing
- Early cropping in 2001 reduced total plant dry weight (root weight by 42%; Figure 2 & 3) and percent fruit bud set in Feb. 2002; for example, fruit bud set of 'Bluecrop' at 1.2m was 52% for control plants and 40% for early cropped; 'Duke' was reduced from 69% to 66%, no effect in 'Elliott'
- There was a cultivar by early cropping interaction for yield in 2002; early cropping of 'Bluecrop', in 2000 and 2001, reduced yield in 2002 by 18% compared to control plants; in 'Duke' early cropping reduced yield 26% and in 'Elliott' 54%
- Early cropping still reduced total plant dry weight in Feb. 2003, but had no effect on percent fruit bud set
- In 2003, early cropping reduced yield only in 'Elliott' compared to the control. Yield was low in 2003 due poor weather during pollination

Conclusions

- Young plants spaced at 0.45m produced from 62% to 140% more cumulative yield than those at 1.2m depending on cultivar. This is similar to our other study (data not shown) where 'Bluecrop' at 0.45m produced 106% higher cumulative yield from years 3 to 8 than those spaced at 1.2m
- 'Bluecrop' seemed to be the best adapted to high density planting and 'Elliott' the least, perhaps due to differences in their top:root ratio – 'Elliott' had a much larger root system
- Early cropping produced economical yields, particularly in 2001 at the high density (averaging 6.5 t·ha^{-1})
- Early cropping in 2001 and 2002 did "stress" plants as evidenced by a reduced plant dry weight and percent fruit bud set
- Early cropping had more impact on 'Elliott' than on 'Bluecrop' and 'Duke', 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 sales is needed in year 2, growers may be able to produce fruit on 'Bluecrop' and 'Duke' without any future negative impact on plant growth or yield

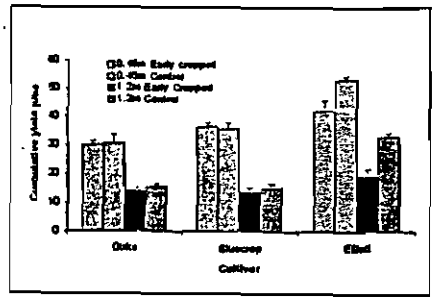


Figure 5 Effect of cultivar and in-row spacing on cumulative yield of early cropped (2000 through 2003) and control (2002 and 2003). Mean ± SE

Results (Figure 5)

- Cumulative yield was significantly affected by early cropping and in-row spacing ($P < 0.0001$). There was a cultivar by early cropping interaction ($P < 0.0001$)
- Cumulative yield was similar for early cropped and control 'Bluecrop' and 'Duke'
- Early cropping reduced cumulative yield 20% to 40% in 'Elliott', depending on in-row spacing

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Research planning in 2003

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Manipulation of the Annual Growth Cycle of Blueberry Using Photoperiod

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Keywords: dormancy, flower buds, *Vaccinium*.

Abstract

A controlled environment study was conducted using container-grown 'Duke', 'Bluecrop' and 'Elliott' from July to December 2002 in Corvallis, Oregon. Plants were placed in growth chambers (GC) under either short-day (SD, 8h of light) or long-day (LD, 16 h of light) photoperiod and constant temperature (22°C) for up to eight weeks. Every two weeks, a group of plants was moved from the GC to a greenhouse (16 h light, 22°C) to measure dormancy, growth, and percentage of flower buds. After eight weeks of SD, a group of dormant plants were moved from the GC to a cold room (4°C) for 900 hours, and then transferred back to the GC (LD and 25°C) to record days to bud break, bloom and fruit ripening. Plants under LD had three to six flushes of growth and did not initiate flower buds or enter endo-dormancy. Bud break occurred after 5 to 15 days in the greenhouse. Plants under SD had two flushes of growth and developed flower buds after two weeks of SD and dormancy after four weeks of SD. The number of flower buds and the degree of dormancy increased with time of exposure to SD. After cold storage, bud break and bloom occurred after 6 and 26 days, respectively, with little differences among cultivars. Fruit harvest started 65, 95, or 130 days after bud break in 'Duke', 'Bluecrop', or 'Elliott', respectively. Fruit set in the GC was reduced due to insufficient pollination.

INTRODUCTION

Photoperiod is an environmental factor that changes in a predictable manner year after year for a particular combination of latitude and day. Plants have evolved to sense these changes and adapt their physiology and metabolism to the oncoming season. Shortened photoperiods in the fall precede cold winters. This is especially important in deciduous woody perennial plants native to high latitudes, which alternate their annual growth cycle between a period of active growth in the spring and summer and one of dormancy in the fall and winter. Highbush blueberry (*Vaccinium corymbosum* L.) is native to latitudes 40 to 45oN, where the natural photoperiod ranges from 16 to 8 hr of light. The influence of short-day (SD) photoperiod on flower bud induction in blueberry is well documented (Darnell, 1991; Hall and Ludwig, 1961; Hall *et al.*, 1963; Spann *et al.* 2003). Lowbush (*Vaccinium angustifoium* Ait.), highbush and rabbiteye (*V. ashei* Reade) blueberry develop flower buds under an 8 hr photoperiod but not under 16 hrs. However there is little or no information on the effect of photoperiod o0n the induction of dormancy and on the possibility to manipulating the annual growth cycle of highbush blueberry using a combination of SD and long-day (LD) photoperiod.

The objective of this work was to quantify the effect of SD and LD photoperiod on the growth, dormancy and flower bud development of three highbush blueberry cultivars under controlled environmental conditions, as well as to artificially manipulate the annual growth cycle of the plant in growth chambers (GC).

MATERIALS AND METHODS

Container grown blueberry (*Vaccinium corymbosum* L.) plants 'Duke', 'Bluecrop' and 'Elliott' were grown in the greenhouse from the end of March until the end of June 2002. Plants were then moved to controlled environment chambers (GC) (Conviron CMP 3023) and grown under either short-day (SD, 8h of light) or long-day (LD, 16 h of light) photoperiod and constant temperature (22°C) for up to eight weeks. At "0" weeks (control plants), and every two weeks, three plants of each cultivar and treatment (SD or LD) were moved to a greenhouse (16 h light, 20°C) and completely defoliated by hand. Degree of dormancy and number of flower buds (FB) were recorded. Dormancy was measured as the number of days to first bud break and FB as the total number on the plant and expressed as a percentage of the total buds. After week eight for the SD plants, a group of dormant plants was moved to a cold room (4°C) for 900 hours, and then transferred back to the GC but under LD and 25°C. Days to bud break, bloom and first ripe fruit were recorded for each cultivar and compared to plants grown under natural conditions (NC).

Shoot length was measured weekly inside the chambers under SD or LD; three shoots on three plants per cultivar were randomly selected for measurements. At the end of the experiment plants from 8 weeks-SD and 8 weeks-LD treatment were destructively harvested to determine the final number of flushes of growth and the total biomass and partitioning in the plants.

Mean values for each measurement were compared using analysis of variance in S-plus.

RESULTS AND DISCUSSION

Growth

Shoot growth cessation and terminal bud set in SD treated plants occured after 2 weeks in 'Elliott' and 'Bluecrop' and after three weeks in 'Duke'. Plants grown under LD photoperiod grew until the end of the experiment (week 8; Fig 1). Plants under LD were taller than SD (Figure 1). Plants grown under LD photoperiod had 4.3 to 5 flushes of growth compared with 2 to 2.7 on plants grown under SD (Table 1). 'Duke' was the cultivar that grew the most under LD conditions. Total plant dry weight was doubled in LD treated plants compared to SD plants (Table 1). Shoot growth cessation due to SD photoperiod has been shown in different plant species such as *Vitis sp* (Fennel and Hoover, 1991; Wacke and Fennell, 2000), poplar (Bañados, 1992; Zhu and Coleman, 2001), birch (Welling *et al.*, 1997), and willow (Barros and Neil, 1987). In this study, SD photoperiod was a very powerful environment clue that even under optimal temperature for growth plants under SD set buds after 2 or 3 weeks.

Dormancy

Non-dormant control plant (week 0) took between 7 to 10 days after defoliation to break buds in a greenhouse. Plants exposed to SD photoperiod developed endo-dormancy after 4 weeks with an increasing number of days to first bud break. Plants were evaluated for up to 4 months after defoliation. Plants treated for 6 or 8 weeks of SD photoperiod did not break bud within that time (Figure 2).

Long-day treated plants broke buds 7 to 25 days after defoliation for week 2 to 6. Plant treated for 8 week of LD took longer to broke buds (40 to 60 days). In those plants

the apical meristems of plants subjected to LD were actively growing when moved to the greenhouse. However the complete defoliation of the plant apparently stressed the pants, delaying the regrowth or budbreak. Dormancy induction due to SD photoperiod has been reported in deciduous woody species. In poplar, 8hr- SD induced dormancy under natural and controlled environmental conditions (Bañados, 1992; Jecknic and Chen, 1999). In many studies, however the effect of photoperiod and temperature is not clearly separated. In this study blueberry plants entered dormancy after 4 weeks of 8hr-SD photoperiod and 22oC.

Flower bud formation

Bud set was observed after two weeks of SD in 'Bluecrop' and 'Elliott' and after 3 weeks in 'Duke' but never under LD. Flower buds were formed only under SD photoperiod and progressed in a quantitative manner with time of exposure (Figure 3). Flower bud number per plant increased in 'Bluecrop' plants from 2 after 2 weeks in SD to 28 after 8 weeks in SD conditions.

The influence of SD in the flower bud formation of blueberries is well documented (Darnell, 1991; Hall and Ludwig, 1961;Hall *et al.*, 1963; Spann *et al.*, 2003) but this is the first report that compare the effect of photoperiod in three different highbush blueberry cultivars, an early, mid season and late season.

Phenological stages

Plants treated for 8 weeks of SD plus 900 chilling hours broke buds 7 to 10 days after being placed in a GC under LD and 25oC. Bloom occurred within one month and first mature fruit for 'Duke' was observed on December 20, 180 days before that it occurred under natural conditions. 'Bluecrop' and 'Elliott' did not differ from 'Duke' in the time of budbreak or bloom, but the first mature fruit on these cultivars was observed on January 22 and February 25 respectively. These results corresponded to 155 to 170 days before plants grown under natural environment conditions (Table 3).

CONCLUSIONS

Short-day photoperiod stopped shoot growth of highbush blueberry after two or three weeks of treatment. Terminal bud formation was observed in the plants at the time of growth cessation and precedes flower bud formation. In contrast LD plants grew continuously in the growth chambers until the end of the experiment.

Plants treated with SD for 4 or more weeks developed endo-dormancy and did not broke buds after four month (end of the experiment) under greenhouse conditions. Long-day plants did not show endo-dormancy and broke buds 7 to 40 days after defoliation in the greenhouse.

Flower bud formation occurred only under SD photoperiod.

ACKNOWLEDGEMENTS

We thank the EPA and USDA in Corvallis, Oregon for allowing us to use their controlled environment chambers for this study, and to the Oregon Blueberry farms for donating the plants for this study.

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Table 1: Flushes of growth and biomass partitioning in container grown blueberry plants 'Bluecrop', 'Duke' and 'Elliott under long-day (LD) or short-day (SD) photoperiod

		Flushes of growth	Leaves (g)	shoots (g)	1-year-wood (g)	Crown (g)	Roots (g)	Total DW (g)
Bluecrop	LD	4.3	37.60	36.79	13.77	11.81	64.61	164.57
	SD	2.7	13.80	16.20	11.70	5.71	27.82	75.23
		*	NS	*	NS	*	*	*
Duke	LD	5.0	24.79	39.87	16.27	24.32	60.99	166.24
	SD	2.3	12.07	7.70	10.24	9.24	28.56	67.80
		*	*	*	*	ns	**	**
Elliott	LD	4.3	38.55	40.38	17.20	17.19	81.89	195.20
	SD	2.0	15.87	18.07	14.93	11.40	44.83	105.10
		*	**	**	NS	NS	*	**

NS, *, **, ***: non-significant, or significant at $p < 0.05$, $p < 0.01$ or $p < 0.001$ respectively

Table 2: Number of flower buds in container grown blueberry plants 'Bluecrop', 'Duke' and 'Elliott' grown under long-day (LD) or short-day (SD) photoperiod.

		Weeks under treatment				
		0	2	4	6	8
Bluecrop	LD	0	0	0	0	0
	SD	0	2	18	25	28
		NS	*	***	***	***
Duke	LD	0	0	0	0	0
	SD	0	2	12	12	14
		NS	*	***	***	***
Elliott	LD	0	0	0	0	0
	SD	0	0	20	28	22
		NS	NS	***	***	***

Table 3. Dates to budbreak, bloom and first mature fruit in container grown blueberry plants 'Bluecrop', 'Duke' and 'Elliott in growth chamber (GC) or natural conditions (NC) in Corvallis, Oregon, USA.

		Budbreak		First Bloom		First mature fruit	
Duke	GC	November 1, 2002	(-125 days)	November 16, 2002	(-130 days)	December 23, 2002	(-175 days)
	NC	March 5, 2003		March 30, 2003		June 20, 2003	
Bluecrop	GC	November 1, 2002	-125 days)	November 16, 2002	(-131 days)	January 22, 2003 June 20, 2003	(-160 days)
	NC	March 5, 2003		April 1, 2003		July 7, 2004	
Elliott	GC	November 5, 2002	-123 days)	November 18, 2002	(-132 days)	February 25, 2003	(-155 days)
	NC	March 8, 2003		April 4, 2003		July 30, 2003	

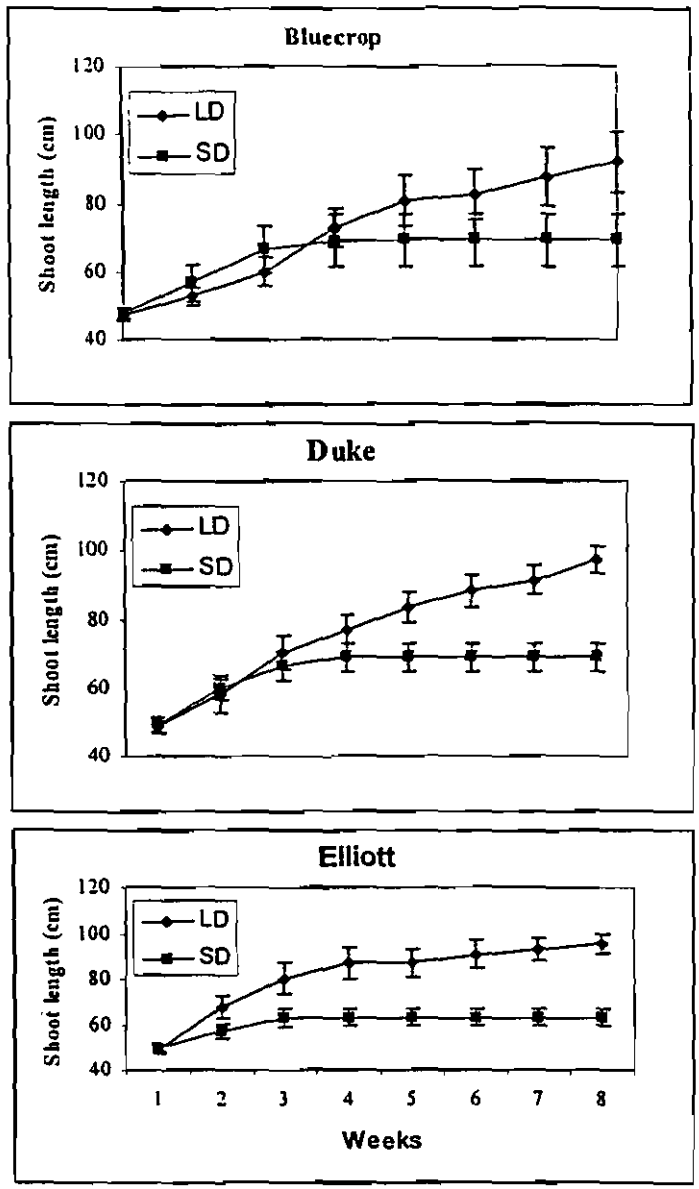

Figure 1. Shoot length of three blueberry cultivars grown in a growth chamber under long days (LD) or short-days (SD) photoperiod. Means ± SE (n=3).

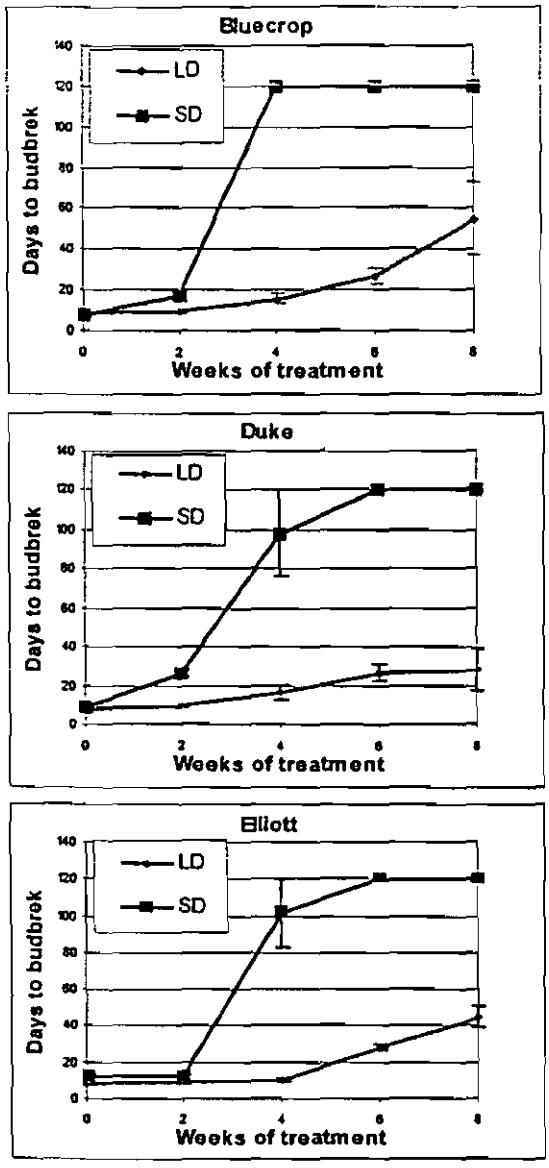

Figure 2. Days to budbreak in 'Bluecrop', 'Duke' and 'Elliott' plants treated with SD or LD photoperiod. Means ± SE (n=3).

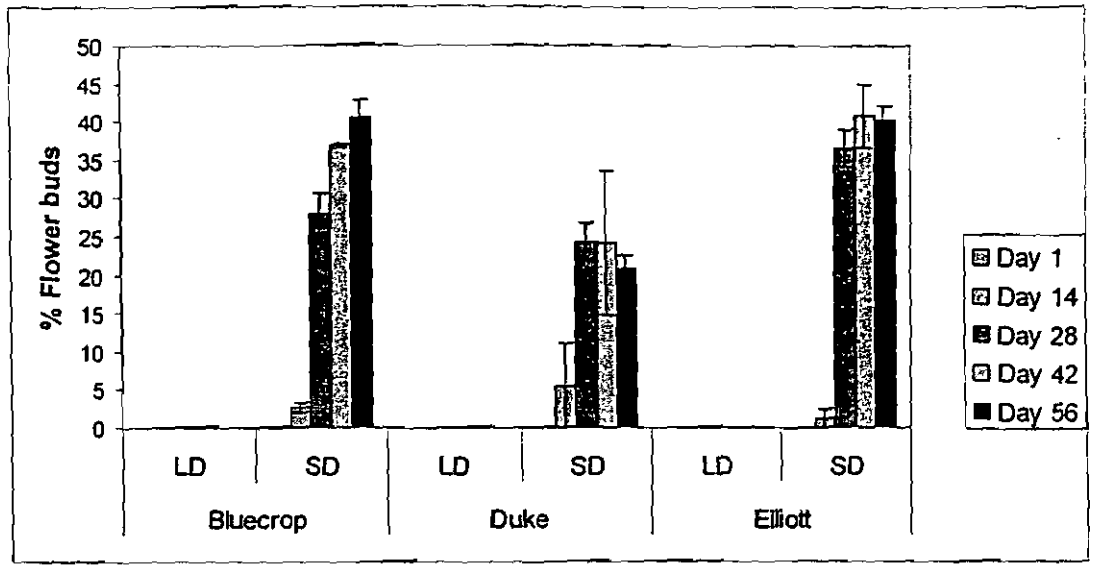

Figure 3: Percent flower bud (%) in blueberry plants 'Bluecrop', 'Duke' and 'Elliott under long-day (LD) or short-day (SD) photoperiod. Values are mean of three plants. Bars indicate SE.

11.actividades de Difusión
(listado de asistencia y referencias)

Act 11.1 y 11.2 las personas ubicables todas a través de la casa Matriz de VBMSA

Proyecto FIA –PL-L-2004-1-A-006

Nombre propuesta: VIII Symposium Internacional sobre el cultivo de Vaccinium"

Fecha	tipo de actividad	Objetivo	Información a Entregar
Martes 25 Mayo	**Entrega conclusiones A los Agrónomos Zonales de VBM**	**Que estos conozcan Lo sucedido en Symposium**	**Informe Final**

ASISTENTES

Zona 1 Cristián Arancibia .....

Zona 2 Jorge Moya .....

Zona 3 Claudio Áuil .....

Zona 4 Sergio Rebolledo .....

Ginnette Pifffaut .....

Ramón Jorquera .....

Zona 5 Alberto Erhardt .....

ARANDANOS: Charla Protocolo Tesco Nature's Choice

Cooperativa Comulco 15 de Julio 2004 (Coollipull).

Nombre	Empresa
1- Daisy Aburto H.	Soc. Agrícola La Selva.
2. Carlos Vásquez	Soc. Agrícola La Selva.
3.) Andrés Bentjerodt	Soc. Agrícola La Selva
4.) Gastón Cabezas	Agrícola San José Ltda.
5. Claudio Sepúlveda	Agrícola San José Ltda
6 Pablo Lira	Rhoss Inversiones SA
7 Juan Salinas	Rhoss Inversiones S.A.
8. Alex Retamal Baxton	→ Gastón Neumet S.
9 Hugo Diermont Romero	Vitroplant
10- [illegible] Muñoz Díaz	Vitroplanta
11- Luis Sepúlveda Ramos	Vitroplanta
12- Elías Fernández	Fdo. los Mayos.
13 Héctor Leiva.	Fdo. los Mayos.
14 Yonhy Reyes Salvo	Fdo. Cien Cuadras
15 María Espinoza	Fdo. Cien Cuadras - Aurora
16.- Carlos Vidal	Fdo. La aurora.
17 Carlos Quintana	Fdo: Taitamito
18 Hugo Salazar	Fdo. Taitamito
19 Leonel Rojas	Agrícola Vitroplanta. L. [illegible]
20 Guido Vera	Fdo Los [illegible] L. [illegible]
21 Juan A [illegible]	Fdo El [illegible] L Angeles.
22 Gerardo Schmidt H	Fdo Taitamito.

ORIGINAL EN OF. VBM TEMUCO.