ing requirement is about 250 to 350 hours, based on comparison to known standards.

Fruit: Fruits are round to conic, with a slight bulge at the suture, diameter averages 5.5 to 7.2 cm and average weigh is around 120g.

The skin is 25% attractive red with a yellow ground color.

The flesh is golden yellow, clingstone, firm, with good flavor, and a good balance between acidity and sugar. The soluble solids are usually between 12° and 15° Brix and the pH averages 3.6.

Flowering: Flowers are showy and full bloom occurs about mid August, usually 5 days before 'Diamante' (Table 3). The pollen is fertil, usually over 50% in vitro germination (in 10% sucrose and 1% agar media).

Harvest: Harvest is generally in the second half of December, about 120 days after full bloom (Table 3).

Availability: Limited number of scions and budwood are available at the EMBRAPA/CPACT, P.O. Box 403, Pelotas, RS, Brazil, 96001-970.

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Blueberry Cultivar Evaluation on a High pH Site in Missouri

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Abstract

'Bluecrop,' 'Bluejay,' 'Blueray,' 'Berkeley,' 'Collins,' 'Coville,' 'Earliblue,' 'Elliott,' 'Lateblue,' 'Northblue' (half-high), 'Northland,' 'Patriot,' 'Pertic Blue' and 'Spartan' highbush blueberry cultivars were evaluated in south central Missouri during the 1990-1994 seasons. The planting site was a high pH, silt loam, low organic matter soil that was amended with sulfur to lower pH. Plant spacing was 1.2 by 3.0 m on bermed, drip irrigated, shredded hardwood bark mulched rows. Soil pH increased from 5.6 to 7.0 during the trial due to alkaline irrigation water and high exchangeable calcium in the soil. Acidified irrigation water and weekly fertigation gave acceptable growth of some cultivars. 'Earliblue' (early), 'Berkeley,' 'Bluecrop' and 'Northland' (midseason), and 'Coville' and 'Lateblue' (late) were best adapted to this site and these cultural practices.

Introduction

Highbush blueberries are generally grown in soils that are naturally acidic (pH 3.5-5.5), light texture (sandy loam), and high in organic matter (3-20%) (5). An exception to this is in the Ozark region of northern Arkansas, southern Missouri, and northeastern Oklahoma where they are grown in soils that have higher pH, high silt and clay content, and low organic matter. A standard recommendation for Missouri is that soils in the Ozark region with a natural pH above 6.5 should not be planted to blueberries, those with pH of 5.6 to 6.4 are acceptable if amended to lower pH, while those below 5.5 are most desirable (1,4). Successful blueberry production in soils with pH above 5.5 and even 6.0 has been reported, but much more intensive management is required in these plantings (3). A highbush blueberry cultivar trial was established in 1986 at Mountain Grove in south central Missouri on a site with high pH that was initially

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lowered with sulfur amendment, but increased over time. This study reports on cultivars that were most productive under these conditions.

Materials and Methods

The trial was conducted at the Southwest Missouri State University Research Campus at Mountain Grove. The soil is a Viraton series; a silt loam topsoil overlying a cherty silty clay subsoil. A fragipan occurs in the subsoil at 45 to 60 cm depth. Permeability is moderate above the fragipan and very low in the pan. Available water holding capacity is low. Ridges 1.2 m wide by 25 cm high in the center were formed along the intended planting row to increase rooting depth, and improve surface water drainage. Initial soil pH was 6.3 with 2% organic matter. The soil was acidified in 1985 by spreading elemental sulfur along the planting row at 50 g · m^{-2} (500 kg · ha^{-1}) and cultivating it into the soil.

Plant spacing was 1.2 m in-the-row with 3.0 m between rows. Moist sphagnum peat moss (3.8 L) was mixed into each planting hole. On April 18, 1986 the following cultivars were planted: Bluecrop, Bluejay, Blueray, Berkeley, Collins, Coville, Earliblue, Elliott, Lateblue, Northblue, Northland, Patriot, Pertic Blue and Spartan. 'Pertic Blue' was a selection made by a private grower, Emil Pertic of La Paz, Indiana. There were five replications of four plants in a completely randomized design. A 7.5 to 10 cm layer of shredded hardwood bark was used as a mulch along the row and was replenished yearly. Only a minimum of pruning was done in the first four years to the plants. Flowers were removed for three seasons to improve plant establishment. Weed control was by preemergence and directed postemergence sprays (2). Row middles were Kentucky bluegrass sod (*Poa pratensis* L.).

Ammonium sulfate at 125 kg · ha^{-1} actual N was applied yearly, starting in the spring in three applications at six week intervals, over the mulched row from 1986-1990. Additional elemental sulfur was applied along the row at 38 g · m^{-2} (380 kg · ha^{-1}) in 1989. Acidification of irrigation water and the addition of soluble fertilizer in irrigation water (fertigation) was started in 1991 (6). Drip irrigation water was acidified to pH 5.0 and applied to supplement rainfall to obtain 6 to 7 cm . ha^{-1} per week of moisture. Soluble 27N-9P-18K plus micro-nutrients (Fe, Mn, Cu, Zn, Mo, B) and sulfur at a rate that provided 125 kg . ha^{-1} actual N was applied yearly from 1991 through 1994, starting in the spring in 20 weekly applications (TotalGro, Winnsboro, LA

Table 1. Soil sample analyses[z] of blueberry cultivar trial at SMSU, Research Campus, Mountain Grove, MO, 1985-1993.

Year	$pH_{(s)}$[y]	P (kg/ha)	K (kg/ha)	Ca (kg/ha)	Mg (kg/ha)	Organic matter (%)	NA (meq/ 100g)	CEC (meq/ 100g)	Calcium base saturation (%)
1985	5.7	59	315	1536	362	2.4	2.0	7.1	47.2
1986	5.6	41	213	1412	465	2.0	2.0	7.1	47.0
1987	4.6	36	237	2388	480	2.7	2.0	9.4	38.4
1988	6.4	39	216	2388	481	4.2	0.5	7.9	65.3
1989	6.1	17	234	1491	337	1.8	1.0	5.8	57.1
1990	6.0	50	131	1995	207	2.2	2.0	7.4	68.9
1991	6.6	39	276	2593	307	2.5	0.5	7.7	72.0
1992	7.4	37	154	3956	221	3.0	0.0	9.8	88.2
1993	7.0	39	176	2631	167	2.5	0.0	6.7	83.4

[z]Soil sample analyses by the University of Missouri Extension Soil and Plant Testing Service, Columbia, Missouri, 65211.
[y]$pH_{(s)}$ determined in a saturated 0.01M $CaCl_2$ solution.

Table 2. Plant height of fourteen blueberry cultivars at the SMSU, Research Campus, Mountain Grove, MO, 1990 - 1994.

	Height (cm)				
Season and Cultivar	1990	1991	1992	1993	1994
Early					
Collins	110 ab[z]	129 ab	140 a-e	146 a-c	149 a-c
Earliblue	95 b-d	105 bc	139 a-e	142 a-c	147 a-c
Patriot	101 b-d	133 ab	143 a-d	147 a-c	151 a-c
Spartan	90 b-d	110 bc	124 c-e	127 b-d	131 b-d
Midseason					
Berkeley	108 a-c	128 ab	158 a	162 a	164 a
Bluecrop	124 a	140 a	151 ab	151 ab	159 ab
Bluejay	83 d	98 c	118 e	115 d	109 de
Blueray	93 b-d	140 a	147 a-c	145 a-c	144 a-c
Northblue	56 e	72 d	86 f	87 e	88 c
Northland	96 b-d	130 ab	127 b-e	142 a-c	146 a-c
Pertic Blue	102 b-d	121 a-c	137 a-e	129 b-d	135 b-d
Late					
Coville	106 a-d	131 ab	143 a-d	144 a-c	145 a-c
Elliott	95 b-d	119 a-c	132 b-e	130 b-d	131 b-d
Lateblue	86 cd	106 bc	121 de	122 cd	127 cd
Yearly Means	96	119	133	135	138

[z]Means separation within columns by Duncan's multiple range test, P = 0.05.

Table 3. Plant yield of fourteen blueberry cultivars at the SMSU, Research Campus, Mountain Grove, MO, 1990 - 1994.

	Yield (kg)					
Season and Cultivar	1990	1991	1992	1993	1994	5 Year Means
Early						
Collins	0.30 e[z]	3.10 a-c	1.58 c-f	3.15 b	1.80 a-d	1.99
Earliblue	0.14 e	2.95 a-d	2.32 bc	3.98 b	1.90 a-c	2.26
Patriot	0.25 e	3.78 ab	0.52 d-f	2.77 b	1.18 b-e	1.76
Spartan	0.24 e	1.00 e	2.10 b-d	3.23 b	0.65 c-e	1.44
Midseason						
Berkeley	0.09 e	4.35 a	2.22 bc	8.34 a	0.60 de	3.12
Bluecrop	1.05 bc	3.23 a-c	3.48 ab	4.61 b	0.90 b-e	2.65
Bluejay	0.35 de	1.95 b-e	2.00 b-e	2.85 b	0.75 b-e	1.58
Blueray	0.81 cd	1.12 de	3.10 a-c	3.62 b	1.02 b-e	1.93
Northblue	0.06 e	1.88 c-e	0.20 f	2.75 b	1.58 a-d	1.29
Northland	0.12 e	2.70 a-e	1.70c-f	4.82 b	2.67 a	2.40
Pertic Blue	0.47 de	3.30 a-c	0.40 ef	3.75 b	1.95 ab	1.97
Late						
Coville	0.81 cd	3.82 a	4.58 a	7.09 a	0.22 c	3.30
Elliott	1.32 ab	1.48 c-e	1.92 b-e	2.93 b	0.68 c-e	1.67
Lateblue	1.67 a	2.78 a-e	2.78 bc	3.43 b	0.93 b-e	2.32
Yearly Means	0.55	2.67	2.06	4.09	1.20	2.12

[z]Means separation within columns by Duncan's multiple range test, P = 0.05.

71295). Iron chelate applications to both soil and plant foliage were made to cultivars that showed iron chlorosis.

Soil samples were taken to a depth of 15 cm in the planting row annually. Sample analyses were by the University of Missouri Extension Soil and Plant Testing Laboratory, Columbia, MO. $pH_{(s)}$ is determined in a saturated 0.01M $CaCl_2$ solution which is usually up to 0.5 pH unit lower than a test in water.

Plant height, spread, cane number, yield, marketable yield, berry weight, and dates of harvest were recorded yearly. One-way analysis of variance was performed on the data and Duncan's multiple range test was used for mean separation.

Results and Discussion

The planting site of fine texture soil with high pH and low organic matter, underlain by a fragipan horizon contributed to slow plant establishment. Only 'Collins,' 'Patriot,' 'Berkeley,' 'Bluecrop,' 'Pertic Blue' and 'Coville' exceeded one meter in height by 1990 after five growing seasons (Table 2). Soil pH increased with time due to high exchangeable calcium in the soil (Table 1) and alkaline irrigation water. Even though soil pH continued to rise (Table 1), growth improved on all cultivars in 1991 after water acidification and fertigation. From 1992 through 1994, all cultivars except 'Northblue,' a half-high cultivar, exceeded one meter height with 'Berkeley' and 'Bluecrop' the highest (Table 2). These heights are well below what can be obtained on a ideal site (5). Spread also exceeded one meter for these cultivars during the same years except for 'Spartan,' 'Bluejay' and 'Northblue' (data not shown). 'Spartan' showed foliar symptoms of iron chlorosis in most growing seasons which reduced its growth. Other cultivars showed intermittent foliar symptoms of iron chlorosis, but none were as severe as for 'Spartan.'

Table 4. Berry weight of fourteen blueberry cultivars at the SMSU, Research Campus, Mountain Grove, MO, 1990-1994.

	Berry weight (g)					
Season and Cultivar	1990	1991	1992	1993	1994	5 Year Means
Early						
Collins	1.0 cd[z]	1.5 de	2.0 cd	1.4 de	1.4 d	1.5
Earliblue	0.8 de	1.2 ef	1.7 de	1.3 e	1.3 d	1.3
Patriot	1.4 a-c	1.5 de	2.5 a	2.0 ab	1.6 b-d	1.8
Spartan	1.5 a	2.4 a	1.9 c-e	2.1 a	2.3 a	2.0
Midseason						
Berkeley	1.0 b-d	2.0 bc	2.3 ab	1.6 cd	1.3 d	1.6
Bluecrop	1.4 a-c	2.0 bc	2.1 bc	1.4 de	2.1 a-c	1.8
Bluejay	1.0 cd	1.6 de	1.3 f	1.3 e	1.4 cd	1.3
Blueray	1.4 ab	2.4 a	1.6 e	1.8 bc	2.1 ab	1.9
Northblue	1.2 a-c	1.7 cd	2.2 ab	1.8 bc	1.6 b-d	1.7
Northland	0.6 e	1.1 f	1.4 f	1.3 e	1.0 d	1.1
Pertic Blue	1.3 a-c	1.7 cd	2.0 cd	1.6 cd	1.4 cd	1.6
Late						
Coville	1.1 b-d	2.2 ab	1.7 de	1.7 cd	1.5 b-d	1.6
Elliott	1.1 a-c	2.1 ab	1.2 f	1.6 cd	1.6 b-d	1.5
Lateblue	1.2 a-c	1.9 b-d	1.8 de	1.5 c-e	1.5 b-d	1.6
Yearly Means	1.1	1.8	1.8	1.6	1.6	1.6

[z]Means separation within columns by Duncan's multiple range test, P = 0.05.

Highbush blueberry bloom occurred the second week of April in southern Missouri. Harvest started the second week of June and extended through the first week of August for early through late cultivars (data not shown). Yields per plant were very low in 1990 (Table 3). Only 'Bluecrop,' 'Elliott' and 'Lateblue' exceeded one kilogram per plant that year. Yields increased substantially for most cultivars in 1991 after the start of water acidification and fertigation with the exception of 'Spartan,' 'Blueray' and 'Elliott.' The highest fruiting years were 1992 and 1993. Flower loss exceeded 90% on 'Patriot,' 'Northblue' and 'Pertic Blue' following a –8.3°C temperature on March 12, 1992 which is a reason for their low yields that year. The remaining cultivars had less than 25% flower loss. Low yields in 1994 were largely due to bird depredation. Midseason and late cultivars ripening the third week of June and after were most susceptible to bird feeding. Five year means showed 'Earliblue,' 'Berkeley,' 'Bluecrop,' 'Northland,' 'Coville' and 'Lateblue' exceeding two kilograms per plant (Table 3). 'Collins,' 'Patriot,' 'Blueray,' 'Pertic Blue' and 'Elliott' were between 1.6 and 2.0 kilograms per plant for five year means. These are acceptable commercial yields for Missouri, but well below the potential yield that can be obtained on an ideal site (5).

Marketable yield exceeded 90% of total yield in most years and five year means showed all cultivars above 80% (data not shown). In 1992 when spring frost reduced yield of 'Patriot,' 'Northblue' and 'Pertic Blue,' frost rings on the fruit of these cultivars reduced their marketable yield below 65% of total yield.

Berry weight varied considerably from year to year. Five year means showed berry weight as low as 1.1 g for 'Northland' to as a high as 2.0 g for 'Spartan' (Table 4). Smallest berries (1.3 g or below) were harvested from 'Earliblue,' 'Bluejay' and 'Northland' with the largest berries (1.8 g or above) from 'Patriot,' 'Spartan,' 'Bluecrop' and 'Blueray.' The remaining cultivars Collins, Berkeley, Northblue, Pertic Blue, Coville, Elliott and Lateblue were between 1.5 and 1.7 g for five year means.

The ideal site for highbush blueberry production has a naturally low pH, light texture soil, and high organic matter (5). In many locations in the Ozark region of Missouri, less than ideal sites with higher pH, heavy texture soil, and low organic matter are planted to blueberries (1,4). Amendment with sulfur prior to planting will lower pH, but high exchangeable calcium in the soil will cause a rise in pH. In this situation, the use of acidified irrigation water and fertigation will give acceptable growth of highbush blueberries (6). The application of foliar iron chelate sprays is considered too expensive and labor intensive. Our evaluation showed that 'Earliblue' (early), 'Berkeley,' 'Bluecrop' and 'Northland' (midseason), and 'Coville' and 'Lateblue' (late) were best adapted to this site and these cultural practices.

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