DOI : 10.5958/0974-0112.2017.00035.4

Indian J. Hort. 74(2), June 2017: 156-161

Evaluation of different blueberry genotypes under mid-hill conditions of Himachal Pradesh

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ABSTRACT

Southern highbush blueberry genotypes, namely, Gulf Coast, Jewel, Misty, Sharpblue and two rabbiteye genotypes, *viz.*, Alapaha and Austin were evaluated for growth, flowering and fruiting behavior under mid hill conditions of Himachal Pradesh during 2014-16. The variability among genotypes was observed for their growth habit, foliar characteristics, flowering and fruit quality attributes. Genotype, Misty exhibited single stem trunk with spreading and upright growth habit, whereas, all other genotypes including rabbiteye exhibited multi-stem trunk. However, southern highbush genotype Jewel had more spreading growth habit with vigorous cane having wide crotch angle as compared with other genotypes. In Alapaha, the bush structure was more compact with upright branching having thin and week cane growth. The genotypes also exhibited great variation in leaf shape, colour and size. The variation in flowering and fruiting behavior was also observed among them, Gulf Coast and Misty were earliest to bloom, while Austin was last. Similarly, Gulf Coast and Misty were the earliest in berry maturity. First picking date in Gulf Coast and Misty was on April 25 and harvesting was continued upto first week of May, while Austin was last (last week of May to first week of June). There was also a great variation in the physico-chemical properties of berries among cultivars. The pooled data of three years showed maximum (1.83 g) berry weight in Jewel whereas; Austin produced smallest berries (0.98 g). Similarly, the total soluble solids and titratable acid contents also varied significantly. All genotypes including rabbiteye type had TSS content more than 10% which has been reported as minimum quality index in blueberries. Based on this study it can be concluded that all southern highbush blueberry genotypes as well as two rabiteye genotypes were found promisisg and thus can be grown in northern parts of India where soil is acidic and winter is cool enough to meet-out the chilling requirements.

Key words: Blueberry, performance evaluation, mid hill conditions.

INTRODUCTION

Blueberries (*Vaccinium* spp.) are native to the north-eastern United States, now becoming important commercial fruit worldwide (Jimenez *et al*., 8). Most of the cultivated highbush blueberries are northern highbush (*V. corrymbosum*), which are being grown in cooler regions of the world, however, with the development of low chilling new southern cultivars its production to the southern and warmer areas has increased. The southern highbush blueberries are hybrids and have greater heat tolerance with lower winter chilling requirement than northern highbush blueberries. Similarly, rabbiteye blueberries (*V. virgatum* syn. *V. ashei* Reade) are native to the southeastern United States were developed in regions with long, hot summers, and they behaved differently in the Pacific Northwest than in their home environments (Bernadine *et al.*, 2).

Nutritionally, blueberries are good source of carbohydrates, vitamins, anthocyanins and several minerals, besides they also contain high amount of iron. Blueberries also provide fair amounts of bioactive compounds with high antioxidant activities, such as flavonoids (flavonols, anthocyanins and others) and phenolic acids (Schotsmans *et al*., 12).

In India, its commercial cultivation has not been reported yet but could be a potential future crop for diversification and nutritional security (Jayant, 7; Negi *et al*., 10). In Himachal Pradesh, highbush and rabbiteye genotypes, *viz*., Jewel, Misty, Bluecrop, Gulfcoast, Primadonna, Sharpblue, Duke, Alapaha and Springwide were introduced at Palampur in 2006-07. Out of these, only Jewel, Misty, Gulf Coast, Sharpblue and Alapaha survived and adapted. Similarly, two rabbiteye genotypes, *viz*., Austin and Brightblue were transferred from National Plant Genetic Resource, Shimla, India to Palampur and were planted at the same location but only Austin survived and acclimatized well to prevailing conditions and now bearing fruits. Thus, an attempt was made to see the possibilities of blueberry production in Himachal Pradesh, where soil is slightly acidic and winter is cool enough to meet the chilling requirements for southern highbush and rabbiteye blueberries.

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MATERIALS AND METHODS

The present study was carried out CSKHPKV, Palampur, during the year 2014-16 on four southern highbush blueberry genotypes, *viz*., Jewel, Misty, Gulf Coast, and Sharpblue along with two rabbiteye types Austin and Alapaha. The experimental field is situated at 1,240 m above mean sea level and 32°8' E latitude and 76°3' N longitude. The area represents sub-temperate sub-humid mid hill of the state, soil is clay loam with pH 6.0 and the climate is humid, temperature sometimes reaches up to 35°C during summer, winters are relatively cold with occasional snowfall and heavy rains during three months (June to August). The plants were planted on raised beds at 1.5 m × 1.5 m distance, to avoid waterlogging during rainy season. The plants were given only FYM and the basin area of each plant was incorporated with pine needles and shredded barks but the data on lowering of pH by pine needles and barks was not recorded.

Plant characteristics, *viz*., growth habit, branching density, branch angles, colour of juvenile growth, matured cane colour and defoliation pattern were observed visually and from each cultivars foliar characteristics, *viz*., leaf sprouting/ emergence date, leaf shape, colour of leaf blade, lamina and foliage pattern were recorded. Leaf size and area, leaf fresh and dry weight was determined. Fruit quality attributes (weight, size, TSS, acidity and TSS: acid ratio) were recorded as per standard methods for three years. The quality parameters were estimated following standard procedures (AOAC, 1). The experiment was laid on randomized block design with three replications and each replication constituted one plant. The data on fruit quality attributes were recorded for three years and pooled. The whole data thus obtained was analyzed by using DOS based statistical software Assex at 5% level of significance.

RESULTS AND DISCUSSION

The data on vegetative growth and plant characters, *viz*., growth habit, branching density and pattern, juvenile growth cane colour, colour of mature cane and defoliation during winter were recorded and presented in Table 1. It is clear from the data that all genotypes irrespective of species had multi-stem, upright and spreading growth habit except Misty, had single stem with weak and lanky growth. However, growth was more spreading with canes having wide crotch angles in Jewel as compared to other cultivars. Alapaha produced thin new canes, more upright with small internodal length and Sharpblue a southern highbush blueberry exhibited less spreading with upright growth, however overall growth of new cane was more as compared to Alapaha and Austin (data not presented).

Branching density in rabbiteye cultivar Alapaha was more among other genotypes, followed by Jewel and sparsely dense in Misty (data not presented). The growth of new cane was stout and vigorous in Jewel and in Alapaha it was observed weak and thin. The crotch angle also varied among the genotypes, it was observed wide and spreading type in Jewel, Gulf Coast and narrow in genotypes Misty and Sharpblue. The colour of juvenile growth was observed light green to silvery green in different genotypes. Similarly, genotypes also exhibited varying cane/shoot colour at maturity and it was observed green in genotypes; Misty, Gulf Coast, Sharpblue and pinkish-grey in Alapaha. In Austin, the mature cane was slightly grayish and in Jewel it was green with slight pink ting on them. Tree morphology is a major characteristic

Table 1. Plant characteristics of southern highbush and rabbiteye blueberry genotypes.

Genotype / Trait	Jewel	Misty	Gulf Coast	Sharpblue	Alapaha*	Austin*
Growth habit	Multistem and spreading	Single stem and Upright	Multistem and upright	Multistem and upright	Multistem and upright	Multistem and upright
Density of branches	Dense and stout	Sparse and weak branches	Dense	Dense	Highly dense thin canes	Sparse
Branch angle	Wide	Narrow	Wide	Narrow	Medium	Medium
Branching pattern	Spreading	Spreading and lanky growth	Spreading	Upright spreading	Spreading with small internodes	Upright and lanky growth
Juvenile growth	Light green	Pinkish green	Light green	Dark green	Pinkish green	Silvery green
Cane colour	Green with pink ting	Green	Green	Green	Pinkish	Grayish green
Defoliation during dormancy	Partially	Partially	Partially	Partially	Fully	Fully

*Rabbiteye blueberry

feature of any genotype, which is governed by genetic makeup and prevailing climatic factors of that region. There was complete defoliation in both types of rabbiteye blueberry genotypes in dormancy, whereas, in all southern highbush defoliation varied from 60 to 90 per cent (data not presented).

After dormancy, leaf bud unfolding is a major event that determines the adaptability of particular genotypes to that particular region. In this study, it was observed that, all four southern highbush genotypes along with Alapaha (rabbiteye) started leaf bud bursting/unfolding in the month of February (Table 2a). Misty was earliest amongst the genotypes (February 7), while in Austin this event was late and leaf emergence was observed in second week of March. Most of the southern highbush blueberry genotypes required less chilling hours as compared to northern genotypes (Francis *et al.*, 5). The leaf lamina/ blade shape was simple and unifoliate in all genotypes but there was variation in leaf colour among different genotypes (Table 2a). The matured leaf lamina colour was dark green in Sharpblue, green in Jewel, light green in Misty and Gulf Coast, whereas, in Alapaha it was slight pinkish and in Austin silvery green. Similarly, variation was also observed in leaf lamina shape, which varied from elliptic to obovate elliptic. It was observed ovate elliptical in Jewel, obovate in Austin and rest of the genotypes (Misty, Gulf Coast, Sharpblue and Alapaha) had elliptical leaf shape. Foliage pattern also varied among the genotypes (Table 2a) and it was observed highly dense in rabbiteye genotypes Alapaha followed by highbush blueberry genotypes; Sharpblue, Jewel and Gulf Coast, however, foliage was sparse in Austin and Misty. The other quantitative foliar characteristics like; leaf lamina length, width, area and weight (fresh and dry) of the different blueberry genotypes also varied significantly (Table 2b). The maximum leaf lamina length and width (8.43 and 3.81 cm) was observed in rabbiteye genotypes Austin and minimum was recorded in Alapaha (3.74 and 1.80 cm). Similarly, leaf area and weight were also significantly higher in Austin as compared to other genotypes except Jewel in which the fresh and dry weights were maximum (0.40 and 0.20 g/ leaf) as compared to other genotypes.

All the southern highbush blueberry genotypes initiated opening of flowers in the month of January (Table 3), whereas, in both rabbiteye genotypes this event was late. Accordingly, the full bloom stage was observed earliest in Gulf Coast on February 15 followed by Misty (February 16), Jewel (February 20) and Sharpblue (February 22). However, in both rabbiteye genotypes this stage was observed late,

Table 2a. Leaf characteristics of southern highbush and rabbiteye blueberry genotypes.

Genotype / Trait	Jewel	Misty	Gulf Coast	Sharpblue	Alapaha*	Austin*
Leaf shape	Simple	Simple	Simple	Simple	Simple	Simple
Leaf colour (blade)	Dark green	Light green	Light green	Medium green	Pinkish green	Silvery green
Leaf lamina shape	Ovate-elliptical	Elliptic	Elliptic	Elliptic	Elliptic	Obovate-elliptic
Leaf lamina margin	Entire	Entire	Entire	Entire	Entire	Entire
Leaf emergence	10 February	7 February	10 February	25 February	2 March	15 March
Foliage pattern	Dense	Sparse	Dense	Slightly dense	Highly dense	Sparse

*Rabbiteye blueberry

Table 2b. Leaf characteristics of southern highbush and rabbiteye blueberry genotypes.

Trait / Genotype	Leaf lamina length (cm)	Leaf lamina width (cm)	Leaf area (cm^2)	Leaf weight (g/leaf)	
				Leaf fresh weight	Leaf Dry weight
Jewel	6.03	3.60	17.75	0.41	0.20
Misty	5.32	2.83	16.94	0.37	0.14
Gulf Coast	5.26	2.99	15.36	0.25	0.12
Sharpblue	7.07	3.51	17.82	0.34	0.18
Alapaha*	3.74	1.80	8.76	0.15	0.08
Austin*	8.43	3.81	18.22	0.39	0.19
CD (P=0.05)	0.17	0.21	1.48	0.03	0.02

*Rabbiteye blueberry

Table 3. Flowering behavior of different blueberry genotypes.

Trait \ Genotype	Jewel	Misty	Gulf Coast	Sharpblue	Alapaha*	Austin*
Start date of flowering	21 January	18 January	16 January	26 January	20 February	20 March
End date of flowering	9 March	2 March	1 March	11 March	11 April	8 May
Full bloom period	20 February	16 February	15 February	22 February	10 March	22 April
Bloom period (days)	47	43	44	44	50	48
Colour of opened flower	White	White	White	White	Pink	Slightly pinkish

*Rabbiteye blueberry

in Alapaha full bloom stage was observed in March 10 and in Austin it was observed April 22. There was a less variation in respect of colour of opened flower or corolla. It was observed slight pinkish in Alapaha and pink in Austin and all the southern highbush types had white coloured flowers. Flowering is also another important event in any plants for determining the outcome and economy of those plants. Flower bud differentiation and flowering are governed by various factors, and in this study all genotypes under observation successfully adapted the prevailing climate and soil conditions and thus established well under sub-temperate sub-humid mid hills of Himachal Pradesh, India. However, in a study by Timothy *et al.* (13) reported that the process of flowering in *Vaccinium darrowi* and southern highbush blueberry was photo-periodically sensitive and promoted by short days, while flower bud development was enhanced under long days. The vegetative and reproductive development in both *V. darrowi* and *V. corymbossum* hybrids was profoundly influenced by photoperiod and increasing vegetative growth was positively correlated with increasing photoperiod in several species, including northern highbush and lowbush blueberry (Hall and Ludwig, 6). However, the role of photoperiod in flower bud initiation in southern highbush blueberry genotypes is unknown and observations of southern types on the Corindi Plateau of New South Wales, Australia indicated that flower bud initiation occur year round (Wright, 14).

In all four southern highbush blueberry genotypes, harvesting commenced from the last week of April and earliest amongst them were Misty and Gulf Coast (April 25 each) in the year 2015-16, followed by Jewel (Fig. 1, 2, 3). Among rabbiteye genotypes, Alapaha was early to mature as compared to Austin. The former genotype attained 25% maturity on May 21 in the year 2015 and May 18 in 2016. Overall harvesting duration, *i.e*. date of first harvesting to last picking date for all genotypes was 42 and 46 days in the year 2015-16, respectively (Fig. 1 & 2). In a study by NeSmith (11) concluded that rabbiteye cultivars Alapaha and Climax took 82 days from 50 percent bloom to attain 50% ripening stage at 10 sites in USA. However, Austin a rabbiteye blueberry reached 50% anthesis 10 days later than rabbiteye cultivar Climax in Alapaha region of Southern Regional Blueberry Evaluation trials (Georgia), therefore, it reached 50% ripe stage slightly later than Climax at

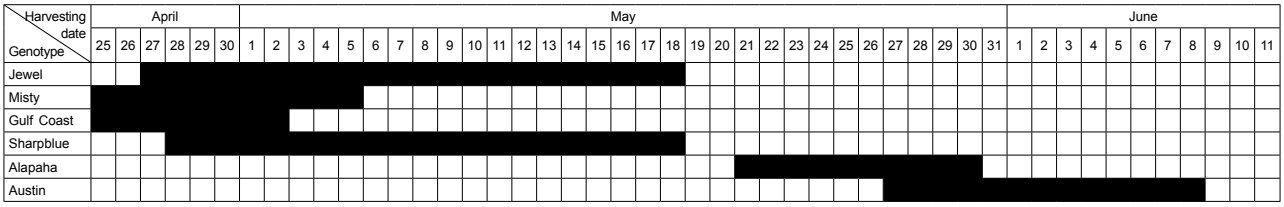

Fig. 1. Harvesting duration of southern highbush and rabbiteye blueberry genotypes (2015).

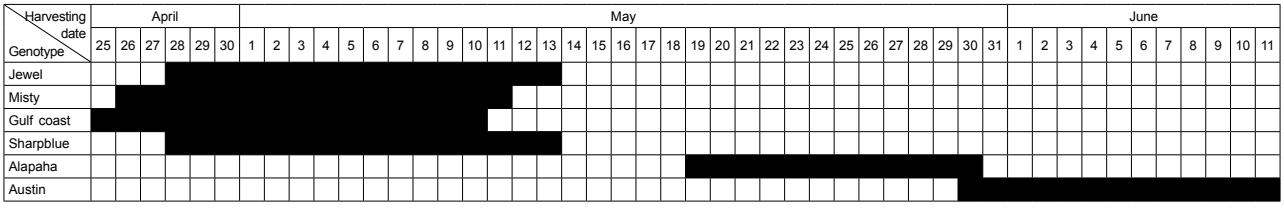

Fig. 2. Harvesting duration of southern highbush and rabbiteye blueberry genotypes (2016).

Fig. 3. Different blueberry genotypes. a; Jewel, b; Sharpblue, c; Misty, d; Gulf Coast (Southern high bush blueberry) and e; Austin; d; Alapaha (rabbiteye blueberry).

two other stations and slightly earlier at one location.

The various berry quality attributes like; length, breadth, weight, TSS, acidity and TSS/acid ratio with respect to genotypes were found significantly different (Tables 4 & 5). It is clear from the pooled data for three years (2014, 2015 and 2016) presented in Table 4 that fruit length was recorded maximum in Misty (1.49 cm), breadth and weight was observed maximum in Jewel (1.84 cm and 1.83 g, respectively). Whereas, minimum of all these quality attributes were observed in Alapaha, *i.e.* 1.15 cm, 1.40 cm and 0.99 g, respectively. The data on total soluble solids, acidity and TSS/acid ratio for three years were pooled and is presented in Table 5. It is clear from the table that maximum soluble solids content was recorded in Misty, followed by Gulf Coast and minimum (10.44%) in Alapaha. Similarly, the genotypes also showed significant variation in titratable acidity and maximum (0.83%) was recorded in Austin and lowest in Gulf Coast, *i.e.* 0.57%, along with Jewel and Alapaha having 0.67% each. Total soluble solids to acid ratio also varied significantly among the genotypes (Table 5) and was observed maximum (20.21) in Gulf Coast and minimum in Austin. All the genotypes had soluble solids concentration higher than 10%, which has been proposed as a minimum quality index for blueberries (Kazim *et al*., 9).

The predominant organic acid in most of the highbush blueberry cultivars was citric acid (83%), while other organic acids such as succinic, malic and quinic acids were approximately 11, 2 and 5 per cent, respectively, however, in rabbiteye blueberries (*V. ashei*) the predominant organic acids were succinic and malic acid with 50 and 34%, respectively (Ehlenfeldt *et al*., 4). During the three year period, all the genotypes yielded soluble solids concentration higher than 10 per cent. Similarly, soluble solids to titratable acid ratio ranged from 12.81 to 20.21, Gulf Coast had maximum value due to its low acid content.

Based on the above findings it can be concluded that all the four southern highbush as well as both

Table 4. Berry quality of southern highbush and rabbiteye blueberry genotypes.

Trait / Genotype	Length (cm)				Breadth (cm)				Weight (g)			
	2014	2015	2016	Pooled	2014	2015	2016	Pooled	2014	2015	2016	Pooled
Jewel	1.40	1.36	1.41	1.39	1.78	1.88	1.86	1.84	1.65	1.98	1.86	1.83
Misty	1.37	1.42	1.44	1.41	1.63	1.57	1.64	1.61	1.41	1.64	1.62	1.56
Gulf Coast	1.22	1.19	1.18	1.20	1.58	1.57	1.58	1.58	1.44	1.63	1.66	1.58
Sharpblue	1.31	1.23	1.24	1.26	1.67	1.72	1.71	1.70	1.52	1.72	1.77	1.67
Alapaha*	1.18	1.19	1.21	1.19	1.68	1.62	1.74	1.68	1.53	1.12	1.42	1.46
Austin*	1.17	1.14	1.13	1.15	1.32	1.35	1.40	1.36	0.89	1.06	1.01	0.99
$CD_{0.05}$	0.04	0.04	0.05	0.02	0.03	0.10	0.07	0.04	0.11	0.06	0.06	0.06

*Rabbiteye blueberry

Table 5. Berry quality of southern highbush and rabbiteye blueberry genotypes.

Trait / Genotype	TSS (%)				Titratable acidity (%)				TSS/acid ratio			
	2014	2015	2016	Pooled	2014	2015	2016	Pooled	2014	2015	2016	Pooled
Jewel	10.27	11.23	12.30	11.27	0.70	0.69	0.61	0.67	14.56	16.20	20.16	16.97
Misty	11.42	12.13	13.51	12.36	0.79	0.77	0.66	0.74	14.73	15.81	20.48	16.89
Gulf Coast	10.07	10.23	14.20	11.50	0.57	0.58	0.57	0.57	17.64	17.93	25.07	20.21
Sharpblue	10.05	10.01	14.12	11.39	0.70	0.71	0.60	0.65	14.23	14.17	23.48	17.12
Alapaha*	10.98	10.38	11.97	11.11	0.67	0.69	0.66	0.67	16.36	15.02	18.01	16.58
Austin*	10.16	10.09	11.13	10.46	0.88	0.89	0.71	0.82	11.52	11.30	15.61	12.75
$CD_{0.05}$	0.314	0.35	1.20	0.45	0.069	0.072	0.064	0.050	1.92	2.12	3.61	2.22

*Rabbiteye blueberry

rabbiteye blueberry genotypes have shown good response to the prevailing agro-climatic conditions and hence, these genotypes can be grown in India.

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Received : February, 2017; Revised : May, 2017;
Accepted : May, 2017