J. Hortl. Sci.
Vol. 4 (1): 28-31, 2009

Expression of genetic variability and character association in raspberry (*Rubus ellipticus* Smith) growing wild in North-Western Himalayas

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ABSTRACT

The present investigation was carried out in various districts of Himachal Pradesh, Jammu & Kashmir and Uttarakhand States falling under north-western Himalayan region of India. As a result of sustained exploration, 170 wild raspberry genotypes were marked and studied for berry quality attributes. Variation ranged from 0.25 g - 0.93 g for berry weight. Berry length varied between 6.31 mm and 14.46 mm, while, berry breadth was 7.02 mm to 15.91 mm. Variation in Total Soluble Solids (TSS) in berry ranged between 9.6°B and 18.6°B whereas, acidity in berries ranged between 1.02 and 1.72%. The range of variation was 2 - 4.90% for reducing sugars, 4.2° - 11.6° for non-reducing sugars and 2.4- 5.2 mg / 100 g for ascorbic acid. Berry weight had significant and positive correlation with its length and its breadth. Berry length exhibited positively significant correlation with berry breadth.

Key words: Raspberry, variation, heritability, berry quality, correlation

INTRODUCTION

Raspberry (*Rubus ellipticus* Smith) is one of the tastiest wild fruits growing in abundance throughout North-western Himalayas. Besides providing essential nutrients for human diet, it has great potential in agro-processing industries in preparation of squash, jam, yoghurt and ice-cream. Worldwide, this small fruit is distributed throughout the sub-temperate Himalayas between 700 m to 2000 m above mean sea level and in West Sikkim, Bhutan, Khasi hills and Burma upto Yunnan province of China. In the South, it grows in the Western Ghats from Kanara to Ceylon. This fruit has successfully been introduced into Florida, USA, for edible and ornamental purposes and for breeding in Australia (Jennings, 1988). Though raspberry has captured the interest of botanists and herbalists, it remains a neglected and unexploited fruit crop for fruit breeders in India (Singh and Kumar, 2001).

The existing, wild population of raspberry comprising shrubs of unknown origin exhibits tremendous variability in growth, flowering, yield and fruit quality attributes, thereby providing a platform for exploitation. Till date, no systematic research work has been conducted from the standpoint of developing this as a new crop, in particular, through collection and selection of superior clones.

It is, therefore, imperative to study genetic parameters like heritability, correlations, and path coefficient analysis for identification and selection of superior genotypes for use either as cultivars or as suitable parents in future hybridization programmes. Findings presented in this communication are a part of the first ever study conducted in India on *Rubus ellipticus* Smith.

MATERIAL AND METHODS

A field survey of North-western Himalayas was undertaken during the years 2007 and 2008 in sub-tropical to wet-temperate areas of Solan, Shimla, Mandi, Kullu and Chamba districts of Himachal Pradesh; Kathua, Udhampur, Samba, Jammu and Reasi districts of Jammu and Kashmir; and Dehradun, Rishikesh, Uttarkashi and Tehri Garhwal districts of Uttarakhand. Geographical Information System data of the areas surveyed were recorded with the help of GPS (GPS MAP-76, Germin, Taiwan). Geographical features of the area surveyed are as under:

Altitude : 760 to 1950 m amsl

Latitude : $30^0$10'159" to $33^0$04'693"N

Longitude : $74^0$44'076" to $78^0$25'681"E

As a result of sustained exploration in collaboration with local inhabitants, as many as 170 raspberry genotypes growing scattered were marked. On the basis of berry quality traits, 37 genotypes were further shortlisted for study. A random sample of 30 fruits in three replicates was taken from each raspberry genotype and observations were recorded on fruit quality characters *viz*., berry weight (g), berry length (mm), berry breadth (mm), TSS (^{0}B), acidity (%), reducing sugars (%), non-reducing sugars (%), vitamin C (mg/100g) and berry colour. Berry size was measured with digital Vernier calipers (Mitutoyo, Japan-CD-6"CS), berry weight with electronic balance, TSS by digital refractometer and acidity, sugars and ascorbic acid as per standard procedures given by Ranganna (1986).

The contribution of each character for every genotype was subjected to analysis of variance (ANOVA) as per standard statistical procedures. The genotypic and phenotypic coefficients of variation were estimated using standard formulae. Heritability in a broad sense was calculated according to the formula suggested by Hansen *et al* (1956) at 5% selection intensity, while, direct and indirect effects of independent traits on berry weight were also estimated.

RESULTS AND DISCUSSION

The analysis of variance showed that mean squares due to genotypes were significant for all the traits included in the study (Table 1). Estimates of range in variation, average mean performance, genotypic and phenotypic coefficients of variation, heritability and genetic advance at 5% selection intensity, are presented in Table 2. The range in variation was 0.25-0.93 g for berry weight. Various workers have reported berry weight ranging between 0.72 and 9.00 g (Mladin, 2002; Dossett, 2007; Mladin and Mladin, 2008; Kim *et al*, 2008; Milutinovic *et al*, 2008; and Weber *et al*, 2008). Berry length varied between 6.31 and 14.46 mm while berry breadth was 7.02-15.91 mm. Earlier studies by Mladin and Mladin (2008), Kim *et al* (2008), and Milutinovic *et al* (2008) revealed variation in berry length and berry breadth ranging between 7.3 and 26.9 mm and 12.2 and 27.4 mm, respectively. Relatively lower values of physical berry characters of berry recorded are perhaps due to the fact that the plants studied grew under minimal cultural conditions as against well-managed cultural conditions reported from elsewhere. Variation in berry TSS was between 9.60 and18.60 ^{0}B whereas, acidity per cent in the berries ranged between 1.02 and1.72%. Berry TSS and acidity ranging between 5.1 and 16.8^{O}B and 0.3 and 3.09% has been reported by various workers in different *Rubus* species (Mladin, 2002 and Dossett, 2007). The range of variation was 2.00-4.90% for reducing sugars, 4.20-11.60% for non-reducing sugars and 2.40-5.20mg / 100 g for ascorbic acid. Ascorbic acid content ranging from 23.5 to 63.66 mg / 100 g was observed by Mladin (2002). However, overall mean performance was 0.54 g for berry weight and 13.74^{0}B for TSS.

This variation offers scope for wild raspberry genetic improvement even within indigenous populations and, suitable donors can be identified accordingly. In addition, genotypic and phenotypic coefficients of variation were almost identical in expression. The high estimates of

Table 1. Analysis of variance for some quantitative traits of horticultural importance in raspberry (*Rubus ellipticus* Smith)

Trait	Mean squares		
	Replication	Treatment	Error
Degree of Freedom (d.f.)	2	169	338
Berry weight (g)	0.003	0.048*	0.001
Berry length (mm)	0.062	5.462*	0.039
Berry breadth (mm)	0.053	5.851*	0.044
TSS (^{0}B)	0.0001	10.594*	0.06
Acidity (%)	0.0004	0.050*	0.002
Reducing sugars (%)	0.076	1.079*	0.032
Non- reducing sugars (%)	0.048	2.996*	0.04
Ascorbic acid (mg /100 g)	0.096	0.602*	0.027

*P < 0.05

Table 2. Estimation of range, mean, PCV, GCV, heritability and genetic advance for berry weight and component traits

Trait	Range	Mean ±SE	PCV	GCV	Heritability(%)	Genetic advance
Berry weight (g)	0.25-0.93	0.54±0.02	24.11	23.13	0.92	9.70
Berry length (mm)	6.31-14.46	10.15±0.11	13.38	13.24	0.98	7.46
Berry breadth (mm)	7.02-15.91	12.17±0.12	11.56	11.43	0.98	6.93
TSS (^{0}B)	9.60-18.60	13.74±0.14	13.76	13.64	0.98	7.57
Acidity (%)	1.02-1.72	1.32±0.03	10.18	9.59	0.89	6.19
Reducing sugars (%)	2.00-4.90	3.07±0.10	20.13	19.28	0.92	8.85
Non- reducing sugars (%)	4.20-11.60	7.08±0.12	14.31	14.03	0.96	7.64
Ascorbic acid (mg /100 g)	2.40-5.20	3.86±0.10	12.14	11.35	0.87	6.71

Table 3. Correlation coefficient at genotypic (G) and phenotypic (P) level for berry weight and component traits

Trait		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1	G	1.000	0.390*	0.332*	-0.005	0.040	0.097	0.095	-0.093
	P	1.000	0.368*	0.316*	-0.001	0.029	0.087	0.090	-0.080
X_2	G		1.000	0.633**	-0.058	-0.060	-0.036	0.095	0.000
	P		1.000	0.622**	-0.056	-0.057	-0.030	0.092	0.001
X_3	G			1.000	0.028	-0.019	-0.141	0.055	-0.053
	P			1.000	0.028	-0.020	-0.133	0.054	-0.051
X_4	G				1.000	0.069	-0.191	0.063	0.082
	P				1.000	0.062	-0.180	0.062	0.078
X_5	G					1.000	0.076	-0.011	-0.039
	P					1.000	0.065	-0.016	-0.036
X_6	G						1.000	0.291	-0.101
	P						1.000	0.272	-0.091
X_7	G							1.000	0.145
	P							1.000	0.131
X_8	G								1.000
	P								1.000

X_1 = Berry weight (g) X_5 = Acidity (%)
X_2 = Berry length (mm) X_6 = Reducing sugars (%)
X_3 = Berry breadth (mm) X_7 = Non-reducing sugars (%)
X_4 = TSS (^{0}B) X_8 = Ascorbic acid (mg /100g)

* Significant at 5% level
** *Significant at 1% and 5% level*

Table 4. Direct (in diagonal) and indirect (other values) effect of berry weight and component traits in *Rubus ellipticus* Smith

Trait	Effect via:							Correlation with berry weight
Berry length (mm)	**0.299**	0.097	-0.002	-0.003	-0.004	0.003	0.000	0.390*
Berry breadth (mm)	0.189	**0.153**	0.001	-0.001	-0.016	0.002	0.004	0.332*
TSS (^{0}B)	-0.017	0.004	**0.030**	0.003	-0.022	0.002	-0.006	-0.005
Acidity (%)	-0.018	-0.003	0.002	**0.048**	0.009	0.000	0.003	0.040
Reducing sugars (%)	-0.011	-0.022	-0.006	0.004	**0.113**	0.010	0.008	0.097
Non- reducing sugars (%)	0.028	0.008	0.002	-0.001	0.033	**0.035**	-0.011	0.095
Ascorbic acid (mg /100 g)	0.000	-0.008	0.003	-0.002	-0.011	0.005	**-0.079**	-0.093

* Significant at 5% level
Residual Effect 0.8997

heritability coupled with low genetic advance observed in all the traits reveal presence of non-additive gene effects. High percentage of heritability is due to favourable influence of environment rather than due to genotype and selection for such traits may not be effective.

Genotypic and phenotypic correlation coefficients among eight traits are presented in Table 3. Berry weight had significant and positive correlation with berry length and berry breadth. Berry length exhibited positively significant correlation with berry breadth. Similar association among these characters was observed by Kim *et al* (2008) in *Rubus coreanus* Miq. and by Moore *et al* (2008) in *Rubus idaeus* L.

In path analysis, seven of the eight berry traits were considered as casual variables and berry weight was taken as a dependent variable. Direct and indirect effects of various traits are presented in Table 4. Berry length and berry breadth had significant and positive effect on berry weight. Significant and positive correlation between different pairs can prove helpful for genetic improvement of different characters, in a single step, if the higher or lower value of each is required, while the negatively associated traits where increased or decreased value of both characters is required cannot be improved in a single step. Characters having non-significant correlation suggest that these are independent of each other.

ACKNOWLEDGEMENT

The authors are thankful to Department of Science & Technology, Govt. of India, New Delhi, for providing necessary financial help during the course of investigation under the project entitled, "Studies on biodiversity of raspberry (*Rubus ellipticus* Smith) for selection of superior genotypes growing wild in north-western Himalayas".

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(MS Received 21 January 2009, Revised 15 May 2009)