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Evaluation of yield attributes of wine varieties of grape under Telangana Conditions

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ABSTRACT

Thirteen wine grape varieties of which eight coloured and five white were evaluated for flowering, bunch characters and yield attributes under Telangana conditions at Grape Research Station, Hyderabad. Observations recorded on flowering, bunch characters and yield attributes revealed that days taken for 50% flowering varied significantly from minimum of 25.36 days in the variety PusaNavrang to maximum of 44.37 days in Thompson Seedless. The variety Chenin Blanc recorded highest number of bunches per vine (113.78) followed by Shiraz (97.75) and least in the variety Thompson Seedless (37.26) where as maximum bunch weight was noticed in the variety Italia (331.61 g) followed by Thompson Seedless and minimum in Cabernet Sauvignon (88.06 g). Yield ranged from 4.51 to 16.81 kg/vine with maximum recorded by the variety Chenin Blanc (16.81 kg/vine) while it was minimum with Sauvignon Blanc (4.51 kg/vine). Heat unit requirement in different cultivars of grape varied from 1726.25 degree days to 2207.46 degree days being recorded maximum by the variety Italia and minimum by Pusa Navrang. These results signify the potential for cultivation of wine grape varieties under Southern Zone of Telangana.

Key words : Wine grape varieties, Flowering, Bunch number, Bunch weight, Bunch length, Fruit yield, Heat unit requirement

Introduction

The genus *Vitis* comprises of three natural groups based on geographical locations viz., North American, Eurasian and Asiatic. American and Asiatic group have 25-30 species whereas Eurasian has only one species, i.e. *vinifera* which has contributed for advancement of grape cultivation throughout the world. The domesticated grape (*Vitisvinifera* L.) is one of the oldest cultivated plants reported to be originated in middle east. Grape cultivation in India has been commercially taken up under a wide range of soil and climatic conditions. Major grape-growing states are Maharashtra, Karnataka, Telangana, Andhra Pradesh, Tamil Nadu, and the north-western region covering Punjab, Haryana, western Uttar

Pradesh, Rajasthan and Madhya Pradesh.

Lack of cold storage facilities and single type of market i.e. fresh fruit trade create a market glut, resulting in the fall of prices and financial loss to the growers and traders. Hence, there is an urgent need to diversify grape usage as juice and wine which can ease out the marketing problems. The wine sector is currently demonstrating positive and dynamic growth mainly due to a change in lifestyle, health consciousness and awareness about wine as a healthy drink rather than an alcoholic beverage. Although India is traditionally not a wine drinking country, but the Indian wine industry has been steadily growing over the last decade. Wine is gradually becoming a part of urban Indian life style. This shows the need for development of wine indus-

try in Telangana, for domestic as well as for export market. As a preliminary step there is a need to find the suitability of growing grape wine varieties for wine making, Keeping this in view, an experiment was proposed to evaluate flowering, bunch characters and yield attributes of wine varieties of grape with an objective to find the suitability of growing wine varieties under Southern Telangana Zone.

Materials and Methods

An experiment was conducted to study the growth performance of wine varieties of grape at Grape Research Station, Rajendranagar, Hyderabad. Thirteen wine grape varieties of which eight coloured and five white were evaluated during the year 2006-07 and 2007-08 to determine their suitability for wine preparation. The varieties are Zinfandel, Cabernet Sauvignon, Shiraz, Ruby Red, PusaNavrang, Bangalore Blue, Athens and Gulabi are the red varieties whereas, Symphony, Chenin Blanc, Sauvignon Blanc, Thompson Seedless and Italia are the white varieties. Observations on flowering, berry characters and yield attributes *viz.*, Days taken for 50% flowering, number of bunches, bunch weight, bunch length, fruit yield and heat unit requirement were recorded during the two cropping seasons, First

Year (2006-07) and second year (2007-08) and data were analyzed statistically.

Results and Discussion

Days taken for flowering

The data recorded on days taken for flowering was furnished in Table 1 which indicated that the experiment was significant in respect of varieties, years while it was found to be non significant with their interaction.

The different varieties screened here have shown statistical differences among themselves in both years and in their mean number of days taken for flowering. The pooled data signify that Pusa Navrang took significantly less number of days to flowering (25.36) and was on par to Chenin Blanc (26.24) and Bangalore Blue (27.63). The next best variety was Symphony (28.55). On the other hand maximum number of days was taken by Italia (44.37) which was on par with Thompson Seedless (43.56) and Ruby Red (43.39). Remaining varieties recorded intermediate values from 34.54 to 38.23 days.

The number of days taken for flowering significantly varied between the years, being more in the second year of experiment (38.00) than in the first

Table 1. Days taken for hundred percent flowering in different varieties of grape

Treatments varieties		Days taken for hundred percent flowering		
		First Year	Second Year	Mean
Coloured				
T1	Zinfandel	37.96	34.70	36.33
T2	Cabernet Sauvignon	40.90	35.56	38.23
T3	Gulabi	37.73	34.12	35.92
T4	Shiraz	40.93	35.13	38.03
T5	Bangalore Blue	30.43	24.83	27.63
T6	PusaNavrang	27.56	23.16	25.36
T7	Athens	41.66	34.30	37.98
T8	Ruby Red	45.53	41.26	43.40
White				
T9	Thompson Seedless	46.74	42.00	44.37
T10	Chenin Blanc	29.33	23.16	26.24
T11	Sauvignon Blanc	36.53	32.56	34.55
T12	Italia	45.53	41.60	43.76
T13	Symphony	33.20	23.90	28.55
	Mean	38.00	33.86	
	F-test	SEM	CD at 5%	
	Varieties	*	0.95	2.69
	Years	*	0.37	1.05
	Varieties x Years	NS	1.34	NS

year (32.79). In the year 2006-07, Italia took more number of days for flowering (42.00) closely followed by Thompson Seedless (41.60) and Ruby Red (41.26) which were in the same order. Whereas Pusa Navrang (23.16), followed by Chenin Blanc (23.16) and Bangalore Blue (24.83) recorded minimum days for flowering and were at par with each other.

The picture in 2007-08 is similar to that of the first year. In this year highest number of days to flowering was recorded by Italia (46.74) closely followed by Thompson Seedless (45.53) and Ruby Red (45.53) which were at par whereas Pusa Navrang (27.56) closely preceded by Chenin Blanc (29.33) took less number of days.

The interaction effects was found to be non significant. However, cultivar PusaNavrang took less number of days while Italia took more number of days for flowering in both the years.

Early flowering is an important attribute, as opening of panicles in shortest possible time is most desirable character in grape. The number of days taken for flowering in grape varies with the genetic base of cultivar and environmental conditions (G x E interaction). Bright warm weather results in early flowering than rainy and cool weather (Weaver, 1976). This is most useful in assessing the maturity and early harvesting of berries providing ease to harvest fruit in one or two pickings to reduce the cost of picking. Early flowering resulting in early harvesting is required, particularly in North India, where harvesting often coincides with early monsoon rains, resulting in loss of produce due to diseases etc.

In the present study, time taken for flowering varied from 25.36 to 44.37 days. Based on the results, varieties can be classified as early blooming (PusaNavrang, Chenin Blanc, Bangalore Blue and Symphony) mid (Shiraz, Gulabi, Zinfandel, Athens, Cabernet Sauvignon and Sauvignon Blanc) and late blooming (Italia, Thompson Seedless and Ruby Red). All the varieties took less number of days to flowering during the second year compared to first year, this may be due to difference in the bud burst duration and also to the prevailing climatic conditions. The number of days for flowering was also influenced by the number of degree days or heat units. Under sub-tropical conditions of Punjab a months time was required for different grape cultivars (Jawanda *et al.*, 1965). Whereas under tropical conditions of Bangalore, the varieties Gulabi and

Bangalore Blue needed 47.0 and 33.5 days respectively to reach flowering. Several workers reported range for 50 % flowering from 33.5 to 47.0 days (Jawanda *et al.*, 1965); 19 to 25 days (Nalwadi *et al.*, 1972); 16 to 30 days (Bharat, 1997); 12 to 23 days (Randhawa and Sharma, 1960). The results of the study are in line with the above reports. The number of leaves, leaf area has no relationship and are not associated with flowering. This is a special trait with polygenic in expression and environment plays a very important role.

Number of bunches per vine

The presented data in Table 2 on the number of bunches per vine revealed the following results.

The mean number of bunches per vine varied significantly among the cultivars. Chenin Blanc showed maximum number of bunches (113.78) and was significantly superior over others followed by Shiraz (97.75) and Pusa Navrang (95.53) in descending order, and both were in same order, but superior to others. Whereas Cv. Thompson Seedless showed minimum number of bunches (37.26) preceded by Italia (38.74) and were at par. The rest of the cultivars showed intermediate values ranging from 45.70 in Gulabi to 87.74 in Cabernet Sauvignon.

Years have also shown significant influence on the number of bunches. An increase in mean number of bunches from 62.65 in 2006-07 to 71.63 in 2007-08 irrespective of the cultivars was observed. All the cultivars have shown this increase except Cv. Athens in which the number of bunches decrease from 61.06 in 2006-07 to 59.90 in 2007-08.

In 2006-07, significantly highest number of bunches was observed with Chenin Blanc (101.30) which was superior over others. Significantly lowest number of bunches was observed with Thompson Seedless (34.00) closely preceded by Italia (35.73) and both were in same order but differed from others. The rest of the cultivars recorded the number of bunches per vine in between the two extremes of maximum and minimum number.

In 2007-08 also, similar trend was noticed in the number of bunches per vine. Chenin Blanc produced significantly highest number of bunches per vine (126.26) and was superior over others and Thompson Seedless recorded minimum number (40.53) respectively.

The interaction effect on the number of bunches per vine was non significant.

Mean bunch weight (g)

Data on mean weight of the bunch (g) as recorded during 2006-07 and 2007-08 in respect of different cultivars was depicted in Table 3 from which it was clear that the parameter was responded significantly

to the factor *i.e.*, varieties while it was found to be non significant with years and their interactions.

When the varietal means were considered for evaluation, it was observed that maximum bunch weight was recorded in Italia (331.61 g) followed by

Table 2. Number of bunches per vine in different varieties of grape

Treatments	Varieties	Number of bunches/vine		
		First Year	Second Year	Mean
Coloured				
T1	Zinfandel	64.30	76.63	70.46
T2	Cabernet Sauvignon	85.13	90.36	87.74
T3	Gulabi	43.90	47.50	45.70
T4	Shiraz	87.60	107.90	97.75
T5	Bangalore Blue	52.93	56.73	54.83
T6	PusaNavrang	86.26	104.80	95.53
T7	Athens	61.06	59.90	60.48
T8	Ruby Red	45.20	47.33	46.26
White				
T9	Thompson Seedless	34.00	40.53	37.26
T10	Chenin Blanc	101.30	126.26	113.78
T11	Sauvignon Blanc	50.33	52.86	51.59
T12	Italia	35.73	41.76	38.74
T13	Symphony	66.73	78.70	72.71
	Mean	62.65	71.63	
	F-test	SEM	CD at 5%	
	Varieties	*	2.52	7.19
	Years	*	0.99	2.82
	Varieties x Years	NS	3.57	NS

Table 3. Mean Bunch weight in different varieties of grape

Treatments	Varieties	Mean Bunch weight (g)		
		First Year	Second Year	Mean
Coloured				
T1	Zinfandel	152.33	146.26	149.30
T2	Cabernet Sauvignon	84.36	91.76	88.06
T3	Gulabi	86.73	92.46	89.59
T4	Shiraz	121.80	133.46	127.63
T5	Bangalore Blue	108.10	101.63	104.86
T6	PusaNavrang	113.23	119.20	116.21
T7	Athens	154.23	155.56	154.89
T8	Ruby Red	140.96	132.26	136.61
White				
T9	Thompson Seedless	311.93	303.66	307.79
T10	Chenin Blanc	131.06	145.46	138.26
T11	Sauvignon Blanc	95.03	102.63	98.83
T12	Italia	327.66	335.56	331.61
T13	Symphony	97.23	99.53	98.38
	Mean	148.05	150.72	
	F-test	SEM	CD at 5%	
	Varieties	*	5.25	14.86
	Years	NS	2.06	NS
	Varieties x Years	NS	7.42	NS

Thompson Seedless (307.79 g) but both were independent to each other and superior to the rest of varieties. The next best variety was Athens (154.89 g) and was at par with Zinfandel (149.29 g). Minimum weight of the bunch was observed in Cabernet Sauvignon (88.06 g) closely preceded by Gulabi (89.59 g), Symphony (98.38 g) and Sauvignon Blanc (98.83 g) and all these were at par. The bunches in case of remaining cultivars weighed intermediately ranging from 104.86 g in Pusa Navrang to 138.26 g in Chenin Blanc.

The years have not shown significant effect on weight of bunches. In the first year of experiment (2006-07) Italia has produced heaviest bunches (335.56 g) closely followed by Thompson Seedless (311.93 g) and the Cv. Cabernet Sauvignon has produced bunches with minimum weight (91.76 g) followed by Gulabi (92.46 g) and Symphony (99.53 g) whereas the rest of the cultivars produced bunches of medium weight between the two extremes.

In the second year of the trial, Italia continued to produce heaviest bunches (327.66 g) followed by Thompson Seedless (303.66 g). Similarly Cabernet Sauvignon continued to produce bunches with lighter weight (84.36 g) this year also.

The interaction effects did not exert significant influence on the bunch weight.

Mean bunch Length (cm)

Significant variation among the varieties, years and non significant influence in their interaction are shown by the statistical analysis of the data on the mean bunch length (Table 4).

The mean data of varieties irrespective of the years has indicated that the length of bunch varied significantly among the cultivars. Maximum bunch length was recorded in Thompson Seedless (17.90cm) which was superior to others. Next in line was Italia (17.00 cm) which was followed by Shiraz (12.33 cm) and were independent to each other. The length of the bunch was least in Sauvignon Blanc (6.66 cm) closely preceded by Symphony (7.04 cm) and both were at par. The latter was comparable with Gulabi (7.56 cm). The remaining cultivars recorded intermediate values for the length of the bunches ranging from 8.86 cm to 11.08 cm.

The yearly effect on length of the bunch was significant. Average length of the bunch showed slight decrease from the first year (10.95 cm) to second year (10.11 cm) in all the cultivars except with Cvs. Bangalore Blue and Gulabi.

When the individual years were taken into account, it was observed that in 2006-07, maximum length of bunch was recorded in Cv. Thompson Seedless (19.60 cm) which was at par with Italia

Table 4. Mean Bunch length in different varieties of grape

Treatments	Varieties	Bunch Length (cm)		
		First Year	Second Year	Mean
Coloured				
T1	Zinfandel	10.70	10.83	10.76
T2	Cabernet Sauvignon	8.66	9.40	9.03
T3	Gulabi	7.76	7.36	7.56
T4	Shiraz	13.00	11.66	12.33
T5	Bangalore Blue	8.63	9.10	8.86
T6	PusaNavrang	10.56	11.60	11.08
T7	Athens	9.30	9.70	9.50
T8	Ruby Red	9.20	9.03	9.11
White				
T9	Thompson Seedless	19.60	16.20	17.90
T10	Chenin Blanc	10.16	10.03	10.10
T11	Sauvignon Blanc	6.53	6.80	6.66
T12	Italia	18.80	15.20	17.00
T13	Symphony	6.73	7.36	7.05
	Mean	10.74	10.33	
		F-test	SEM	CD at 5%
	Varieties	*	0.29	0.84
	Years	*	0.11	0.33
	Varieties x Years	NS	0.42	NS

(18.80 cm) and were superior to others. Minimum length of the bunch was observed in Sauvignon Blanc (6.80 cm) closely preceded by Symphony (7.36 cm) and Gulabi (7.36 cm) and were at par. Similar results were recorded during the second year of the trial.

The interaction effect of varieties and years was found to be non significant. Among the varieties, Thompson seedless recorded longest bunches followed by Italia whereas, smallest bunches were recorded by Sauvignon Blanc.

Bunch attributes contribute much to the yield of vines and these are specific to each variety. Heavier the bunches with heavier berries, more the yield of grape varieties. However, they differ in different varieties due to nutrition, place of cultivation etc., Bunch characteristics *viz.*, number of bunches, bunch weight and bunch length were used in describing different grape varieties by several workers (Hedrick, 1908; Bioletti, 1938, Singh and Singh, 1940; Joshi, 1961; Shirsath, 1965; Kashyap *et al.*, 1988; Shanmugavelu, 1989). The bunch characteristics have significant correlation with the fruit yield.

Number of bunches per vine differs significantly with the variety, nutrition of the vine and probable site of growing. In the present study, the number of bunches varied from 37.26 to 113.78 with maximum recorded in the variety Chenin Blanc and minimum in Thompson Seedless respectively. The productivity of bunches, bunch weight and length appears to be a genetic phenomenon, but the climate and soil nutrient status also contribute to certain extent. This difference in the number of bunches per vine may be attributed to varietal character due to more number of canes or immaturity of canes in different varieties. Similar line of work was registered by Kadu (2002) and Havinal (2007). A wide range in number of bunches was reported by several workers *i.e.*, 8 to 88 (Anonymous, 1984a); 9.30 to 33.43 (Kadue *et al.*, 2007); 17.35 to 93.10 (Karibasappa and Adsule, 2008); 58.33 to 142.00 (Ratnacharyulu, 2010); 131 to 162 (Walker *et al.*, 2000). The outcome of the present study is in agreement with the above references.

Bunch weight is an important yield attribute. Bunch weight in the present study found to ranged from 88.06 to 331.61 g with maximum being with the variety Italia and minimum with the variety Cabernet Sauvignon. The differences in the bunch weight in different varieties may be attributed to inherent genetic character of the variety, difference in number of canes, number of berries per bunch

and berry size and also vine canopy size where the high bunch weight was observed in the varieties which had large canopy size (Walker *et al.*, 2000; Havinal, 2007). Several workers reported a range of bunch weight from 28.49 to 317.00 g (Kadu, 2002); 41 to 430 g (Bhujbal, 1972); 44.9 to 431.1 g (Daulta *et al.*, 1972); 60.5 to 194 g (Ghosh *et al.*, 2008); 65.5 to 251.5 g (Karibasappa and Adsule, 2008); 75.7 to 280g (Kumar and Rajan, 2008); 88 to 310 g (Richard *et al.*, 2001); 97.33 to 161.33 g (Ratnacharyulu, 2010). These results of the present study are with the findings of the above workers.

In the present investigation, length of bunch ranged from 6.66 cm (Sauvignon Blanc) to 17.90 cm (Thompson Seedless). A range of bunch length from 10.1 to 15.4 cm (Ghosh *et al.*, 2008); 12.0 to 19.2 cm (Richard *et al.*, 1999); 13.7 to 21.7 cm (Thakur *et al.*, 2008). This type of results on bunch characteristics in different varieties were also reported by Richard *et al.*, (2000), Kadu (2002) and Havinal (2007).

Fruit yield (kg/vine)

The quantity of value added products from the crop and economic returns largely depend on fruit yields. It is customary to record yields in varietal trials and compare them for the ultimate evaluation and selection of high yielder. Yields not only depend on varieties, but also on several other factors, besides prevailing agro-climatic condition, where the crop is raised. With this view, yields of different grape cultivars were recorded during both the years of trial and the recorded data on this parameter were furnished in Table-5.

The statistical analysis of the data in the Table indicated significant variations among the varieties and years and a non significant influence of interaction on fruit yield.

The perusal of pooled data indicates that maximum fruit yield was recorded with the variety Chenin Blanc (16.81 kg/vine) followed by Italia (13.53 kg/vine) and Shiraz (13.48 kg/vine) which were at par. The latter was followed by Thompson Seedless (11.53 kg/vine) which was however, comparable to PusaNavrang (10.78 kg/vine). On the other hand, minimum fruit yield was observed in the variety Sauvignon Blanc (4.51 kg/vine) comparable with Gulabi (4.94 kg/vine). Rest of the varieties were in the range from 6.03 to 9.91 kg/ vine.

Significant difference was noticed with respect to fruit yield in both the years. When the mean yields of both years are compared, it was observed that

mean yield showed significant increase in the second year over the first year.

During the first year, the yield difference among the varieties was significant. In this year Chenin Blanc (15.23 kg/vine) recorded significantly highest yield but was at par with cultivars like Shiraz (12.80kg/vine) and Italia (12.50 kg/vine). Minimum yield was recorded in case of Sauvignon Blanc (4.38 kg/vine) closely preceded by Gulabi (4.53 kg/vine) with which it was at par. The yields of the remaining cultivars were intermediate.

During the second year also significantly highest yields were contributed by Chenin Blanc (18.40 kg/vine) followed by Italia (14.56 kg/vine) and Shiraz (14.16 kg/vine) and were at par. The lowest yield was observed with Sauvignon Blanc (4.64 kg/vine) preceded by Gulabi (5.36 kg/vine).

Interaction between varieties and years showed non significant influence. However, irrespective of the years, the variety Chenin Blanc recorded highest yield per vine while the variety Sauvignon Blanc showed the lowest yield.

The ultimate goal of any grower is the yield, which is the most important factor from commercial point of view. Yield is variable among the different varieties of a crop and is inherent. However, it depends on the age of the plant, nutrition, cultural

practices adopted, on pest and disease incidence and finally place of cultivation *i.e.*, climate of the area. Yield also varies from year to year in the same variety and also when grown at different locations. These facts have been brought about clearly in the present investigation. Wide range of yield among different varieties of grape screened at different location has been reported from India and abroad (Daulta *et al.*, 1972; Thatai *et al.*, 1987; Kadu, 2002; Ramkumar *et al.*, 2002; Ghosh *et al.*, 2008; Shellie, 2007; Karibasappa and Adsule, 2008; Havinal *et al.*, 2008 and Ratnacharyulu, 2010) which support the results of the present study at Hyderabad. The difference in the yield per vine in different grape cultivars might be due to differences in weight of the bunch, number of bunches, weight of the berries and age of the vines besides their successful adoption to the varying agro-climatic conditions under which they are cultivated (Thatai *et al.*, 1987; Havinal *et al.*, 2008).

In the present investigation the yield ranged from 4.51 to 16.81 kg/vine. The variety Chenin Blanc recorded maximum while Sauvignon Blanc showed the minimum yield. Based on this, varieties can be classified as high yielders ranging from 16.81 to 10.78 kg/vine (Chenin Blanc, Italia, Shiraz, Thompson Seedless and Pusa Navrang); medium yielders

Table 5. Fruit yield of different varieties of grape

Treatments	Varieties	Fruit yield (kg/vine)		
		First Year	Second Year	Mean
Coloured				
T1	Zinfandel	9.46	10.36	9.91
T2	Cabernet Sauvignon	7.00	8.44	7.72
T3	Gulabi	4.53	5.36	4.94
T4	Shiraz	12.80	14.16	13.48
T5	Bangalore Blue	5.44	6.62	6.03
T6	PusaNavrang	9.13	12.43	10.78
T7	Athens	8.44	8.78	8.61
T8	Ruby Red	6.66	6.83	6.74
White				
T9	Thompson Seedless	10.50	12.56	11.53
T10	Chenin Blanc	15.23	18.40	16.81
T11	Sauvignon Blanc	4.38	4.64	4.51
T12	Italia	12.50	14.56	13.53
T13	Symphony	6.83	7.80	7.31
	Mean	8.68	10.95	
	C.D. at 5%	2.14	1.19	
		F-test	SEM	CD at 5%
	Varieties	*	0.43	1.24
	Years	*	0.17	0.48
	Varieties x Years	NS	0.62	NS

ranging from 9.91 to 7.31 kg/vine (Zinfandel, Athens, Cabernet Sauvignon and Symphony); and low yielders ranging from 6.74 to 4.51 kg/vine (Ruby Red, Bangalore Blue, Gulabi and Sauvignon Blanc). PusaNavrang yielded 21.5 kg/vine at Lucknow whereas at Hyderabad it yield 10.78 kg/vine. This difference may be due to variation in the climate of both places. Lucknow comes under sub-tropical zone whereas Hyderabad comes under semi-arid tropical zone. Ghosh *et al.*, 2008 from West Bengal reported Pusa Navrang as highest yielder (12.2 kg/vine) among the eight grape cultivars screened.

Thus it is clear that the prevailing climate of the location has a substantial bearing on yield. Yearly effect on yield is also effective, a little higher yield was recorded with second year of study irrespective of the variety. The yield potential of a grape variety is inherent subject to adoption to varying agro-climatic conditions of different locations.

Heat unit requirement

Optimum stage of maturity of fruits is an important factor that influences the quality of wine. The stage of maturity can be judged by heat summation, besides others like days for bud burst and days for anthesis, colour of the stem, transparency of the berries and TSS etc. Hence, heat unit requirement for maturity in different cultivars was worked out

based on the base temperature of grape under semi arid conditions of Hyderabad and were presented in Table 6.

The results in the table indicated that significant influence of the variety, years and interactions on the heat unit requirement. The pooled data implies that Italia required maximum number of heat units (2207.46 degree days) closely followed by Ruby Red (2119.96 degree days). Italia however was statistically superior to other cultivars except Ruby Red with which it was at par. The latter was comparable with Thompson Seedless (2040.16 degree days) and Cabernet Sauvignon (2031.64 degree days). Minimum number of heat units were required by PusaNavrang (1726.24 degree days) closely preceded by Chenin Blanc (1764.11 degree days), Bangalore Blue (1815.79 degree days), Symphony (1816.30 degree days) and all fell in the same order. The rest of the cultivars recorded intermediate values ranging from 1859.70 to 1989.72 degree days respectively.

Years also had influenced the heat unit requirement of different grape cultivars. However, there was less requirement of heat units in the first year than in second year. In the first year of study, Ruby Red recorded higher number of heat units (1984.23 degree days) followed by Italia (1969.73 degree days) while lowest was noticed in Pusa Navrang

Table 6. Heat unit requirement (Degree days) in different varieties of grape

Treatments	Varieties	Heat Units (Degree days)		
		First Year	Second Year	Mean
Coloured				
T1	Zinfandel	1980.30	1872.73	1926.51
T2	Cabernet Sauvignon	2064.63	1914.82	1989.72
T3	Gulabi	1894.20	1825.20	1859.70
T4	Shiraz	1936.20	1878.54	1907.36
T5	Bangalore Blue	1929.36	1834.00	1881.68
T6	PusaNavrang	1720.36	1732.13	1726.25
T7	Athens	2131.26	1932.02	2031.65
T8	Ruby Red	2255.70	1984.23	2119.96
White				
T9	Thompson Seedless	2155.53	1924.80	2040.16
T10	Chenin Blanc	1780.43	1747.80	1764.11
T11	Sauvignon Blanc	1848.34	1784.26	1816.30
T12	Italia	2445.20	1969.73	2207.46
T13	Symphony	1860.26	1771.32	1815.80
	Mean	2000.13	1859.35	
	F-test	SEM	CD at 5%	
	Varieties	*	33.33	94.80
	Years	*	13.70	37.18
	Varieties x Years	*	47.14	134.06

(1720.36 degree days). During the second year, Italia registered maximum heat units (2445.20 degree days) followed by Ruby Red (2255.70 degree days) and minimum was recorded by the variety Pusa Navrang (1732.13 degree days).

Interaction effect on the heat unit requirement was significant. The Cv. Pusa Navrang recorded minimum number of heat units in both the years while Ruby Red in the first year and Italia during the second year recorded higher heat units.

Plant growth and development is proportional to the biological time or thermal time, which can be defined as the integral part of the product of the time and temperature above a threshold level. The concept of heat units is simply to predict phenological stages and has been used to forecast the main stages of plant development.

Varieties exhibit inherent differences in their heat unit requirement. Each variety has a specific heat summation requirement which however, varies under the influence of place of cultivation and time. This has been observed to be true in the present study.

According to Bammi (1968) most of the grape growing areas in India received heat units of 4000 to 4800 degree days in grape from the start of growth to maturity of berries. The requirements of heat units also differed with earliness or lateness of the variety. Makhija *et al.*, (1984) observed that early maturing varieties (Pearl of Csaba) required 1600 degree days, mid season variety (Black Muscat) required 2080 degree days and late season variety (Alam Wick) required 2250 degree days under Delhi conditions and concluded that early maturing varieties required less heat units than the late maturing varieties. Similar observations was made by Thakur *et al.*, 2008.

The requirement of heat units differs from place to place for the same variety. Bangalore Blue required 3562 degree days to attain maturity at Coimbatore (Palaniswamy *et al.*, 1965) whereas it required 1815.79 heat units at Hyderabad in the present study. The heat unit requirement in case of Italia varied from 1727-1840 degree days in different months over a base temperature of 12°C in Brazil (Murakami *et al.*, 2002). In Egypt, Thompson Seedless required 8566 and 12591 heat units for the start and the end of the bud break whereas it required 2040.16 heat units in the present investigation at Hyderabad.

In the present study, heat unit requirement in different cultivars of grape varied from 1726.24 to 2207.46 degree days having recorded maximum by the variety Italia and minimum by the variety Pusa Navrang respectively. Based on this data, varieties can be classified as early maturing (Pusa Navrang, Chenin Blanc, Symphony and Sauvignon Blanc), mid maturing (Gulabi, Bangalore Blue, Shiraz and Zinfandel) while late maturing varieties (Cabernet Sauvignon, Athens, Thompson Seedless, Ruby Red and Italia). The variation in heat unit requirements among the different grape varieties was attributed to the variation in the date of maturity (Thakur *et al.*, 2008). The variation in the heat unit requirement with the variation in the date of maturity was also reported in Ber (Singh *et al.*, 1998) and Mango (Shinde *et al.*, 2001).

Several scientists have reported wide range of heat units from 1600 to 2250 degree days (Makhija *et al.*, 1984); 890.1 to 1491.7 degree days (Thakur *et al.*, 2008). Different cultivars require different heat unit requirement *viz.*, 3562 degree days in Bangalore Blue (Palaniswamy *et al.*, 1965); 2000 degree days in Thompson Seedless and 3284 degree days in Gulabi (Rameshwar, 1993) 1295 degree days in Cabernet Sauvignon (Santos *et al.*, 2007). The results are in accordance with the above findings.

Conclusion

There were significant differences in wine varieties with respect to their influence on yield parameters *viz.*, days taken for 50% flowering, number of bunches bunch weight, bunch length, fruit yield and heat unit requirement. Based on the observations, it became possible to classify the varieties as per the fruit characters and earliness. However, the results clearly indicates the possibility of growing these varieties in Southern Telangana Zone diversifying the grape uses from table grapes to wine grapes.

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