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Heat unit requirement and phenological development of different grape varieties

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Abstract
A field experiment was conducted to work out relationship between heat unit requirement and phenophases of 11 grape varieties during the years 2015-16 at horticulture farm, college of Horticulture, RVSKVV, Mandsaur (M.P.). The varieties flame seedless and Kishmish Charnyi ripen about 27 to 30 days earlier than the late ripening varieties *viz.*, Kishmish Red and Crimson Seedless. For all the phenological stages, the grape varieties under study accumulated more heat units (mean value) during the year (1858.4 °days). Early maturing varieties consumed lesser heat units for fruit ripening, as compared to late ripening varieties. The average fruit yield was observed maximum in A18-3 (2.31 kg/vine) followed by Krishna Seedless and Kishmish Moldowsky (1.95 kg/vine) while the Kishmish Red, Black Seedless and Ruby Seedless were among the lowest fruit yielding varieties. A significant positive correlation was found between heat unit requirement for different phenological phases both at genotypic and phenotypic level.

Keywords: Grape varieties, heat unit requirement, phenological and fruit yield

Introduction
Variation in weather parameters is considered major factors of interannual variability of plant growth and yield. All the crops are vulnerable to different temperature stresses during the crop season and differential response of temperature change to various crops has been noticed under different production environments (Kalra 2008) [9]. Out of all the cultivated plants, the grapevine is considered as one of the most responsive to its surrounding environment. Many factors other than temperature drive viticulture suitability (Jackson and Schuster, 2001) [5], simple to complex indices of temperature are the most common measures used to assess what types of grapes can be grown in which climates (Jones *et al.* 2010) [7].
The occurrence of different phenological events during growing season of any crop and the effect of temperature on plant growth can be inferred using accumulated heat units or growing degree days. Any change in optimum temperature during its vegetative or reproductive growth adversely affects the initiation and duration of different phenophases and finally yield of the fruit plants. The concept of heat units has been applied to correlate the phenological development of different crops to predict yield and physiological maturity (Swan *et al.* 1989; Singh *et al.* 2007) [16, 14]. It is therefore essential to have the knowledge of exact duration of different phenophases in existing environment and their relation with yield determinants, for achieving high yields in grapes. Thus the present study was conducted to assess the performance of different grape varieties in terms of heat unit requirement and fruit yield.

Materials and methods
Eleven varieties of grapes planted at horticulture farm, college of Horticulture, RVSKVV, Mandsaur (M.P.) were used as plant material for the study conducted during the year 2015-16. One vine of each variety planted at 3 × 2 m apart trained on 'Y' trellis System formed one replication. The treatment was replicated thrice in randomized block design. The study area (Mandsaur 24.13^0 N; 75.18°E, 435 m ASL) comes under agro-climatic zone X *i.e.,* Malwa plateau of M.P., India. The mean annual rainfall is about 917.7 mm, 80 percent of which is received during the South-Western monsoon season (First week of July to mid September) and remaining during the winter season.
The weather was taken from the meteorological observatory installed at COH, Mandsaur. The heat units or growing degree days (GDD) were calculated using the following formula (Rai *et al.* 2002) [12]:

GDD or Heat units = Tmean – Tbase

Where, Tmean is the mean temperature and Tbase is the base temperature below which fruit growth is arrested. The base temperature for grapes is taken as 10 °C (Brar *et al.* 1992) [1]. The observations on fruit yield were recorded from each vine and were converted into ton/hactare. Different phenological stages *i.e.,* bud break, panicle initiation, flowering, fruit set and fruit ripening (from February to March) were recorded by observing the vines on every alternate day. The data was analysed as per the method suggested by Gomez and Gomez, 1983. The phenotypic and genotypic coefficients of variation (PCV and GCV) were obtained by the method suggested by Burton and De Vane, 1953 and Johnson *et al.* 1955. Heritability in broad sense and genetic advance (GA) were estimated as per the formulae described by Johnson *et al.*, 1955 respectively.

Results and discussion

The weather data of the year are presented in Fig. 1.

Phenology of grape varieties

Numbers of days taken to attain any phenological event varied across varieties during the year (Table 1). Variety Black Seedless followed by Krishna Seedless and Ruby Seedless took less number of days for all the phenological stages *i.e.*, bud break, panicle initiation and flowering. This may be due to the high temperature during the months of February which results in early bud burst leading to early panicle initiation and flowering. Panicle initiation was earliest in Blak Seedless, Krishna Seedless and Flame Seedless while the maximum days for panicle initiation were taken by Ruby Seedless. The flowering was earliest in Black Seedless followed by Fantasy Seedless, A18-3 and Sharad Seedless while the Ruby Seedless took maximum days for flowering. The varieties Blak Seedless followed by A18-3 were earliest to set fruit. Earlier bud burst in these varieties might be resulting in earlier fruit set. The varieties Flame Seedless and Kishmish Charnyi were among the earlier ripening varieties while the Kishmish Red, Crimson Seedless and Ruby Seedless were among the late varieties. This may be due to the reason that the early maturing varieties took lesser number of days from bud burst to fruit set as compared to others varieties resulting in early ripening and vice versa. This is in accordance with the findings of Mandelli *et al.* (2003) [11] and Gupta *et al*. (2015) [4] for bud burst, panicle initiation, flowering and fruit set in grape.

Heat unit requirement of grape varieties

All the grape varieties under study consumed varied amount of heat units to attain different phenological stages (Table 1). Most of the grape varieties accumulated less heat units resulting in better yield response. Kishmish Charnyi consumed minimum heat units of 1615.3 (° days) while the maximum heat units of 2038.3 ° days were consumed by cultivar Kishmish Red. Makhija *et al.* (1984) [10] also reported that the early ripening varieties consumed lesser heat units as compared the late ripening varieties. The requirements of heat units also differed with earliness or lateness of the variety. This is in accordance with the findings of Shinde *et al.* (2001) [13], Rai *et al.* (2002) [12] and Thakur *et al.* (2008) [17].

Fruit yield (kg/vine)

Fruit yield of the varieties presented in (Table 1). The fruit yield was recorded significantly higher in A18-3 (2.31kg/vine) which was at par with the fruit yield of Krishna Seedless and Kishmish Moldowsky (1.95kg/vine). Kishmish Red were among the lowest fruit yielding varieties. These results are also in conformity with the findings of Thakur *et al*. (2008) [17].

Perusal of the data in table (2) shows differences between phenotypic coefficient of variation and genotypic coefficient of variation for all the phenological traits under study. This indicates presence of greater environmental influence on expression of all these traits and selection may not be effective in the improvement grape. The grape varieties under study have higher phenotypic coefficient of variation than corresponding genotypic coefficient of variation indicating the dominance of environment over genotype in expression of traits under study. The estimation of GCV itself does not helps to determine the extent of heritable variation. Therefore, estimation of heritability indicates effectiveness with which selection may be expected to exploit the genetic variability. Heritability estimates gives a measure of transmission of characters from one generation to the next and the consistency in the performance of progeny in succeeding generations and depends mainly on the magnitude of heritable portion of variation.

The correlation coefficients between different characters are presented in Table 3. Pearson correlation indicated heat unit requirement showed significant correlation between days to flowering (r=0.581), days to fruit set (r=0.608) and days to ripening (r=0.955). Days to flowering was found significantly correlated with days taken to fruit set (r=0.883) and days to ripening (r=0.567). Days to fruit set were found significant associated with days to ripeninf (r= 0.602). Similar findings were reported by Joshi *et al.* (2015), Singh *et al*. (2016) [15] and Thakur *et al.* (2008) [17].

Conclusion

Based on phenological traits, the Black Seedless can be classified in to early variety suitable for cultivation under Malwa plateau of M.P. Early ripening varieties consumed lesser heat units in comparison to late ripening varieties. Kishmish Charnyi consumed minimum heat units. However, A18-3, Krishna Seedless and Kishmish Moldowsky varieties considered to high yielders.

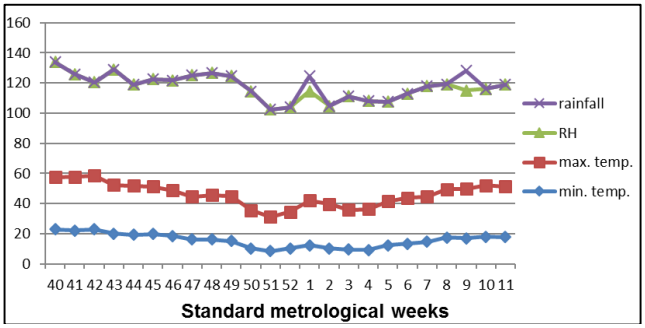

Fig 1: Weekly meteorological observations during the study period (October, 2015 – March, 2016)

Table 1: Mean and Range values of grape varieties for different trait

Treatment details	DBB	DPA	DF	DFS	DTR	HUR (^{0}days)	YPV (kg/vine)
T_1(Sharad seedless	11.00	27.33	43.33	49.67	142.67	1805.8	1.73
T_2 (Krishna seedless)	8.00	26.00	45.67	50.33	153.67	1965.1	1.95
T_3(flame seedless)	12.67	26.00	43.67	50.00	127.33	1640.7	1.93
T_4(A18-3)	12.33	26.67	43.33	47.67	142.67	1805.8	2.31
T_5(Fantasy seedless)	14.00	28.67	43.00	48.33	142.33	1801.5	1.83
T_6 (Kishmish Moldowsky)	11.67	29.00	46.00	51.00	148.00	1873.5	1.95
T_7 (Black Seedless)	7.00	26.00	41.67	45.00	146.00	1848.1	1.53
T_8 (Kishmish Red)	10.33	28.00	44.33	51.00	158.00	2038.3	1.44
T_9 (Crimson Seedless)	11.33	28.00	45.00	51.33	158.67	2015.8	1.77
T_{10} (Ruby seedless)	8.00	29.67	48.33	50.67	156.67	2032.7	1.57
T_{11}(Kishmish Charnyi)	9.67	29.00	45.00	50.33	127.67	1615.3	1.81
Mean	10.54	27.51	44.48	49.66	145.78	1858.4	1.80
Range	7.00	3.67	6.66	6.33	31.34	423.0	0.87

Table 2: Genetic parameters for grape varieties

Traits	PCV	GCV	Heritability (%)	G A	GA(as % mean)
DBB	21.060	15.860	56.714	2.621	24.605
DPA	5.205	3.015	33.570	1.01	3.599
DF	5.375	4.280	63.415	3.074	7.022
DFS	4.500	3.868	73.908	3.366	6.851
DFR	8.736	8.686	98.858	25.421	17.791
HUR(^{0}days)	9.390	9.339	98.930	347.382	19.136
YPV(kg/vine)	127.835	76.406	35.723	0.834	94.075

Table 3: Phenotypic (r_p) and genotypic (r_g) correlation coefficient of HUR and component characters in grapes

Traits	HUR (^{0}days)	DBB	DPA	DF	DFS	DTR	YPV (kg/vine)
HUR (^{0}days)	1.000	-0.319 -0.239	0.007 0.004	0.581 0.460	0.608 0.519	0.955 0.944	-0.506 -0.301
DBB		1.000	0.095 0.042	-0.257 -0.154	-0.048 -0.031	-0.293 -0.219	-0.055 -0.025
DPA			1.000	0.175 0.081	0.188 0.093	-0.008 -0.005	0.111 0.038
DF				1.000	0.883 0.604	0.567 0.449	-0.498 -0.237
DFS					1.000	0.602 0.515	-0.532 -0.273
DTR						1.000	-0.535 -0.318
YPV(kg/vine)							1.000

HUR: heat unit requirement (^{0}days); DBB: days to bud break, DPA: days to panicle appearance, DF: days to flowering, DFS: days to fruit set, DTR: days to ripening and YPV: yield per vine (kg/vine)

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