Pak. J. Bot., 52(3): 1011-1018, 2020. DOI: http://dx.doi.org/10.30848/PJB2020-3(7)

PHENOLOGICAL AND PHYSICOCHEMICAL EVALUATION OF TABLE GRAPES GERMPLASM GROWING UNDER ARID SUBTROPICAL CLIMATE OF PAKISTAN

MUHAMMAD TAHIR AKRAM[1], RASHAD WASEEM KHAN QADRI[1*], MUHAMMAD JAFAR JASKANI[1] AND FAISAL SAEED AWAN[2]

[1]Institute of Horticultural Sciences, University of Agriculture Faisalabad, Pakistan
[2]Centre of Agricultural Biochemistry and Biotechnology (CABB), University of Agriculture Faisalabad, Pakistan
[*]Corresponding author's email: waseemrana_83pk@hotmail.com

Abstract

Eleven grapes cultivars (comprising 4 local and 7 exotics genotypes) were investigated for physicochemical evaluation and to identify early maturing cultivars before monsoon rains that are suitable for arid subtropical climate of Pakistan. Completely randomized design (CRD) with three replications was used in study and differences among means were calculated by Tukey HSD test. On the base of phenological attributes 'Flame Tokay', 'NARC- Black', 'King Ruby' and 'Early white' cultivars exhibited early ripening before monsoon rains. Physical parameters were dominantly present in local cultivars. Local genotype 'Gola' showed highest bunch length (27.50 cm), berry diameter (17.97 mm) and berry weight (5.37 g). While maximum bunch weight (583.55 g) and bunch width (12.33 cm) was observed in 'Kishmish' followed by 'Haita' (579.50 g & 11.70 cm), respectively. However, maximum biochemical attributes were observed in exotic cultivars. Maximum TSS (19.10%), TA (1.36%), total sugars (11.77%) and non-reducing sugars (5.03%) were observed in 'Flame Tokay' while maximum TSS/TA ratio (41.99) was observed in King Ruby and reducing sugars (7.38%) was observed in Sultanina cultivar. 'NARC-Black' was only black color cultivar and was found rich in ascorbic acid contents (28.57 mg 100 g^{-1}). Cluster analysis performed on the bases of biochemical attributes divided into three main groups. Group A was consisted of four exotic genotypes Sultanina, Thomson Seedless, Flame Tokay and Muscat Hambourg, Group C was consisted of only local cultivars Kishmish and Haita while Group 2 was admixture of both local and exotic genotypes. All phenological, physical and biochemical studies showed useful attributes for future grapes improvement programs.

Key words: Arid subtropical; Attributes; Early mature; Phenological; Physicochemical; Table grapes.

Introduction

Grape belongs to family "Vitaceae" is one of the most cultivated crop of world due to its nutritional importance. It is rich source of vitamins, minerals, sugars and organic acids which are the part of human diet and are required for normal growth (Engel *et al*., 2010). In the world grapes are grown for several purposes, 71% of it is used for wine, 27% is used for fresh consumption while remaining 2% is being consumed as dried fruit. In world grapes are cultivated on an area of 75,866 sq. km with 21.94 MMT production (Division, 2013). In Pakistan, its production is increasing annually and currently it is cultivated on an area of nearly 15 thousand ha with 772 thousand tons production (Anon., 2014-15). Above 70% of grapes are grown in Balochistan province while remaining is grown in some districts of Khyber Pakhtunkhwa and Punjab.

Grapes can also be grown in the agro-climatic conditions of Punjab successfully if there is availability of early grown cultivars (Khan *et al*., 2011). In Punjab, monsoon rains are considered as one of the biggest problem and barrier for grapes cultivation. Monsoon rains at the time of fruit maturity causes the berry splitting, cracking and rotting which ultimately gives invitation to different fungal diseases. As sugars and high temperature in summer provides an ideal temperature for fungal growth and development which affects the fruit quality. In order to resolve the rotten berry issue due to monsoon rains, early riping grapes cultivars should be evaluated in terms of physical and chemical characteristics.

The grapes quality depends upon its physical and chemical composition which is greatly affected by biotic and abiotic factors (Ahmad *et al*., 2004). Climate has a profound effect on growth, production and on fruit quality which greatly affects grapes diversity. Factors include in climate are temperature, precipitation, wind, light and humidity of particular area. Among these factors, temperature is the foremost factor that contributes to the successful cultivation of grapes. Temperature average range from 25-30°C is considered ideal for shoot growth and physiological processes (Hunter & Bonnardot, 2011; Pscheidt, 2007; Ramos *et al*., 2013). However, as a temperate plant it required below 10°C for bud burst and 30-35°C for berry ripening. These conditions are successfully fulfilled by Punjab as it temperature goes beyond 2°C in winter and above 40°C in summer. Temperature also effects on color and aroma of grapes (Carey *et al*., 2008). Moreover, grapes quality is also affected by rainfall, frost and humidity during the growing season (Nemani *et al*., 2001). Rainfall directly contributes in production and vigor of vines however indirectly contributes to sugars, acids and phenolic contents of berry (Zamora, 2003).

Climate also greatly affects the physical maturity and biochemical composition of the grapes. Physical maturity is described as a stage when the fruit size, weight and diameter reaches its maximum level whereas the chemical maturity depends on maximum TSS/TA ratio and sugar contents (Khan *et al*., 2008). Topography, soil, climate and substrate are factors which playing their important role in the physical characters of grapes like including time of maturity, time of ripening, yield, color, size, aroma as well as also influence the biochemical characteristics like total soluble solids and total sugars of grape berry (Carey *et al*.,

2008b). In addition to environmental factors, genotype of grape greatly influence the chemical composition of grapes (Liu *et al*., 2006).

Table grapes must have such characters which attract consumers and are preferred by consumers. Flavor and taste composition is the complex attribute of quality which attracts consumers. Among flavor metabolites, TSS and TA are the ordinary parameters which are related with grapes taste (Shiraishi *et al*., 2010). In ripe table grapes, acids are present in small traces as compared to sugars but these acids play their significant role to overall taste (Nelson, 1979). Growers mostly used TSS (sweetness) as a sign of maturity and varieties with TSS from 15-18 Brix are considered mature for cultivation (Munoz-Robredo *et al*., 2011). Quality of grapes also depends upon biochemical characters like pH, acidity, color and TSS (Prado *et al*., 2007). Difference in acidity at harvesting can be due to different environmental conditions, different varieties and other factors like storing conditions (Navarro *et al*., 2001). Similarly, chemical composition is also affected by various factors such as growing condition, maturity stage and cultivar selection (Liu *et al*., 2006).

The grapes phenology is considered as a key factor in grapes cultivation (Köse, 2014). It is also declared as a distinct crop in phenology with most important phenological stages including budburst, bloom, fruit set and harvest (Mullins *et al*., 1992; Pscheidt, 2007). In subtropical regions of Pakistan, grapes bud burst starts in the last week of February to the first week of March after dormancy while the monsoon rains start in early July. So, there is need to evaluate early mature cultivars that will harvest before monsoon season to prevent loss of berry rotting and splitting due to rains. In present scenario, little information is available about early maturing grapes germplasm for cultivation in arid subtropical climate of Pakistan where monsoon rain is of great concern issue. Until now to our knowledge, there is no physical and biochemical evaluation of local and exotic genotypes grown in this region are reported. Hence, the objective of this study was to evaluate early mature cultivars by analyzing phenology of grapes germplasm and to find the physicochemical properties of unexplored grapes germplasm grown under arid subtropical climatic conditions of Pakistan.

Materials and Methods

Plant materials: Eleven ten years old grapes varieties included (Kishmish, Flame Tokay, NARC-Black, King Ruby, Sultania-C, Red Globe, Early White, Thomson Seedless, Haita, Gola, Muscat Hambourg) were selected from Horticulture Research Station, Barani Agriculture Research Institute, Chakwal. Climate data, including daily observations of minimum temperature, average temperature, maximum temperature, rainfall and relative humidity were recorded throughout the study period (Figs. 1 & 2).

Phenological characters: For phenological characteristics, parameters like time of pruning, time of bud burst, time of harvest and time from bud burst to harvest (Days) were taken. All varieties were pruned in mid of January at four to six nodes. Budburst was considered to have occurred when 50% of the plants showed these physiological responses. Similarly, time of harvest was noticed at first picking when fruit was completely mature and attained its proper color. The numbers of days taken by each variety from bud burst to first fruit harvest was also counted.

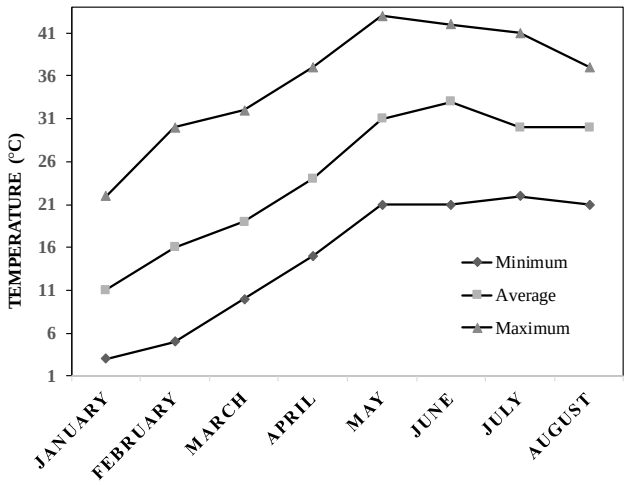

Fig. 1. The minimum, maximum and average temperature of Chakwal, Pakistan recorded from January to August, 2016.

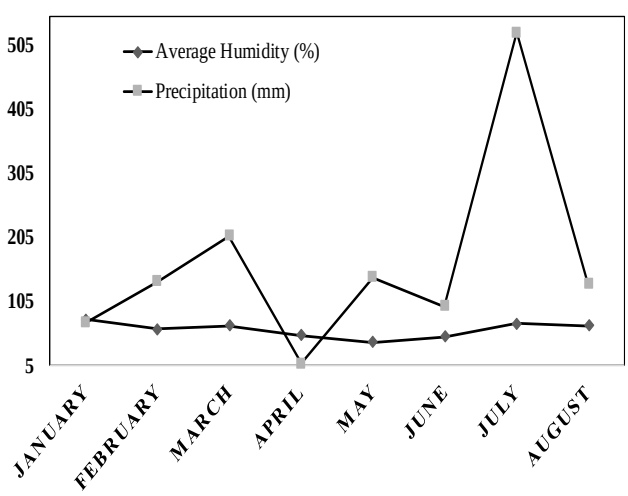

Fig. 2. The average humidity (%) and precipitation (mm) of Chakwal, Pakistan recorded from January to August, 2016.

Physico-chemical fruit quality characteristics: For physicochemical fruit quality analysis after harvesting fruit was taken to Citrus sanitation laboratory, Institute of Horticultural Sciences, University of Agriculture, Faisalabad through a well-ventilated vehicle on the same day. The samples on arrival were stored at 4°C till the analysis. Fruits physical characteristics such as average bunch length (cm), bunch width (cm), bunch weight (g), bunch compactness, numbers of berries per bunch, berry size, berry shape, berry color, berry taste, berry diameter (mm) and weight of single berry (g) were measured and analyzed. Furthermore, fruit biochemical parameters including total soluble solids (TSS, Brix), titratable acidity (TA, %), TSS: TA ratio, pH of berry juice, ascorbic acid contents (VIT C, mg 100 g^{-1}), total sugars (TS, %), reducing sugars (RS, %) and non-reducing sugars (NRS, %) were also determined. For biochemical parameters grapes juice was extracted by twisting berries with the help of Muslim cloth and three replicates of each parameter were taken as replication.

TSS, TA and TSS: TA ratio: For TSS measurement, one drop of extracted grapes juice taken on the mirror of hand refractometer (RS-5000 Atago, Japan) and its value was taken in Brix. While TA was determined by the procedure described by (Khan *et al*., 2011).

pH and vitamin C: The pH of grapes juice was measured by using digital pH meter (HI 98107, Mauritius). First, the tip of the meter was washed and dipped in distilled water to make it neutral then grapes juice reading was taken. However, VIT C contents were estimated by the procedure prescribed by (Ruck *et al*., 1969).

Total sugars, reducing sugars and non-reducing sugars: Sugars in grapes juice were determined by following the method mentioned by (Khan *et al*., 2009).

Statistical analysis: The data was analyzed by analysis of variance (ANOVA) using Statistics software 8.1. The design was simple completely randomized design (CRD) and differences among means were calculated by Tukey HSD test. Single grapevine was used as an experimental unit with at least three replications.

Results

Phonological attributes of grapes genotypes: The grapes cultivars grown under arid subtropical climate of Pakistan exhibited significant in the phenology characters (Table 1). The earliest bud burst was observed in cultivar 'Early White' which starts sprouting 7 days earlier as compared to Flame tokay, King Ruby, Thomson seedless and Gola. The difference between first bud burst and last bud burst was of 14 days. The harvesting dates also showed prominent differences with in the phenology of cultivars. As bud burst took earliest in Early White, it also bears fruiting 2 days earlier as compared to Flame Tokay. Besides with Early white and Flame Tokay, NARC-Black and King Ruby also mature early before monsoon season. Similarly, Flame Tokay and NARC-Black took (99 & 100) days respectively from time from bud burst to harvest. While King Ruby, Sultanina-C and Early White took total 104 days from bud burst to harvest.

Morphological attributes of grapes genotypes: All cultivars showed significant variation in bunch characteristics (Table 2). The maximum bunch length was observed in local cultivar Gola (27.50 cm) followed by Sultania- C (22.33 cm) which is among one of the most cultivated cultivar of Chakwal while the least bunch length was observed in Haita (11.00 cm). The bunch width was also significantly different in different cultivars. The maximum bunch width was observed in cultivar King Ruby (12.50 cm) at par with Kishmish (12.33 cm) while the minimum bunch width was observed in Early white (5.55 cm). In bunch weight character, maximum weight was observed in local cultivars Kishmish (583.55 g), Haita (579.5 g) and Gola (556.5 g) respectively while least weight was observed in local cultivar NARC-Black (77.70 g). The character berries per bunch varied significantly in studied grapes cultivars. Maximum berries per bunch were revealed in Thomson seedless (354) and minimum in NARC-Black (28).

Higher variation in bunch compactness was observed in varieties grown under agro climatic conditions of Chakwal. The cultivars Sultanina-C and Muscat Hambourg consisted of very loose bunches, Gola had loose bunch and early white had medium bunch compactness. Whereas dense bunches were observed in Flames Tokay, NARC-Black, King Ruby, Haita and very dense bunch compactness was observed in Kishmish, Red Globe and Thomson Seedless cultivars.

All the varieties grown under arid subtropical climate of Pakistan showed significant variations in berry characters (Table 3). The berry size from very small to very large was observed in these cultivars. The smallest size was observed in Thomson seedless while local cultivars Haita and Gola showed biggest size. Similarly, there was significant difference observed in berry shape. Red globe was oblate in shape, Sultanina-C and Gola had oblong shape, NARC-Black, King Ruby, Early White and Muscat Hambourg were round while remaining cultivars were obtuse-ovate in shape.

Significant difference was observed in berry diameter weight of single berry. Maximum diameter was measured in King Ruby (18 mm) at par with Gola (17.97 mm) while least berry diameter was observed in Thomson Seedless (10.41 mm). Similarly, maximum berry weight was observed in Gola (5.37 g) while minimum berry weight was observed in Thomson seedless (0.97 g).

Biochemical attributes of grapes genotypes: All grapes accessions showed significant changes in their biochemical characteristics (Table 4). The significant difference was recorded for TSS (%) among grape cultivars grown under agro climatic conditions of Chakwal. TSS observed in these cultivars was in ranged of 19.10 to 10.30%. Maximum TSS was observed in Flame Tokay (19.10 %) followed by Muscat Hambourg (18.40%) and Thomson Seedless (18%) respectively. Whereas maximum TSS: TA ratio was exhibited in King Ruby (41.99%) and minimum TSS: TA was observed in Sultania- C (12.26 %).

The grapes cultivars grown under arid subtropical climate of Pakistan exhibited pH in range between 4.43 to 5.12. The ascorbic acid contents were highest in NARC-Black (28.57 mg 100 g^{-1}) at par with Early White cultivar (28.47 mg 100 g^{-1}) while the lowest content of ascorbic acid was in Red globe (19.9 mg 100 g^{-1}) and Thomson Seedless (19 mg 100 g^{-1}) respectively. In our finding Haita cultivar showed maximum pH (5.12) with least ascorbic acid contents (14.29 mg 100 g^{-1}) whereas NARC-Black showed minimum pH (4.55) with largest VIT C contents (28.57 mg 100 g^{-1}).

Sugars contents were highly varied in grapes cultivars grown under arid subtropical climate of Pakistan (Fig. 3). The total sugars were in ranged from 6.42 to 11.76%. Highest content of total sugars was in cultivar Flame Tokay (11.76%) followed by Thomson seedless (11.29%), Muscat Hambourg (11.23%) and King Ruby (11.09%) respectively. While the least contents of total sugars were observed in local cultivar Kishmish (6.42%). In reducing sugars, its highest content was noticed in cultivar Sultanina-C (7.38%) followed by Flame Tokay (6.74%). The cultivar Flame Tokay also showed its highest non-reducing sugars (5.02%) while both reducing and non-reducing sugars (2.09% & 4.33%) were observed in cultivar Kishmish.

Table 1. Phenological characteristics of different grape varieties grown under arid subtropical climate of Pakistan.

Varieties	Time of pruning	Time of bud burst	Time of harvest	Time of bud burst to harvest (days)
Kishmish	18 January 2016	13 March 2016	10 July 2016	119
Flame Tokay	18 January 2016	09 March 2016	16 June 2016	99
NARC-Black	18 January 2016	13 March 2016	21 June 2016	100
King Ruby	18 January 2016	09 March 2016	21 June 2016	104
Sultanina-C	18 January 2016	16 March 2016	28 June 2016	104
Red Globe	18 January 2016	13 March 2016	10 July 2016	119
Early White	18 January 2016	02 March 2016	14 June 2016	104
Thomson Seedless	19 January 2016	09 March 2016	28 June 2016	111
Haita	19 January 2016	13 March 2016	10 July 2016	119
Gola	19 January 2016	09 March 2016	28 June 2016	111
Muscat Hambourg	19 January 2016	11 March 2016	01 July 2016	111

Table 2. Bunch characteristics of grape varieties grown under arid subtropical climate of Pakistan.

Varieties	Average bunch length (cm)	Average bunch width (cm)	Average bunch weight (g)	Average bunch compactness	Number of berries per bunch (No.)
Kishmish	20.23 ± 0.25c	12.33 ± 0.28a	583.55 ± 3.55a	Very dense	187.00 ± 3.00b
Flame Tokay	12.83 ± 0.76f	9.93 ± 0.12d	193.90 ± 1.10e	Dense	86.33 ± 1.15e
NARC-Black	12.00 ± 0.50f	6.00 ± 1.00 e	77.70 ± 1.90g	Dense	28.00 ± 1.53g
King Ruby	17.50 ± 0.50d	12.50 ± 1.50a	196.70 ± 18.1e	Dense	146.00 ± 14.0c
Sultania- C	22.33 ±0.41b	9.60 ± 0.4d	240.45 ± 11.45d	Very loose	151.50 ± 21.50c
Red Globe	11.83 ± 0.28f	5.75 ± 0.25e	152.65 ± 2.35f	Very dense	58.00 ± 2.00f
Early White	11.93 ± 0.90f	5.55 ± 0.05e	140.00 ± 5.50f	Medium	43.66 ± 3.21fg
Thomson Seedless	22.00 ± 2.0bc	10.50 ±0.50cd	441.50 ± 15.8b	Very dense	354.00 ± 24.0a
Haita	11.00 ± 0.10f	11.70 ± 0.20ab	579.50 ± 20.5a	Dense	160.00 ± 5.00c
Gola	27.50 ± 2.50a	11.00 ± 0.12bc	556.50 ± 13.5a	Loose	112.50 ± 2.50d
Muscat Hambourg	15.25 ± 0.75e	11.25 ± 0.25bc	309.35 ± 64.45c	Very loose	112.50 ± 3.50d

Any two means in a column followed by same letters are not significant at ($p \leq 0.05$), NS = not significant, n = three replicates

Table 3. Berry characteristics of grape varieties grown under arid subtropical climate of Pakistan.

Varieties	Berry size	Berry shape	Berry color	Berry taste	Berry Diameter (mm)	Weight of berry
Kishmish	Medium	Obtuse-ovate	Green-yellow	Sweet	15.71 ± 0.06c	2.63 ± 0.35c
FlameTokay	Small	Obtuse-ovate	Purple red	Sweet	14.84 ± 0.25d	1.48 ± 0.80d
NARC-Black	Large	Round	Black	Sweet	16.04 ± 0.25bc	2.36 ± 0.95c
King Ruby	Medium	Round	Red-grey	Sweet	18.00 ± 1.92a	1.57 ± 0.14d
Sultania- C	Large	Oblong	Green-yellow	Sweet	14.27 ± 0.04ad	2.61 ± 0.68c
Red Globe	Large	Oblate	Red-grey	Sweet	15.89 ± 0.25bc	3.79 ± 0.19b
Early White	Medium	Round	Green-yellow	Very sweet	15.86 ± 0.11c	2.26 ± 0.57c
Thomson Seedless	Very small	Obtuse-ovate	Green-yellow	Sweet	10.41 ± 0.03e	0.97 ± 0.30e
Haita	Very large	Obtuse-ovate	Green-yellow	Very sweet	16.73 ±0.02b	4.04 ± 0.95b
Gola	Very large	Oblong	Green-yellow	Very sweet	17.97± 1.60a	5.37 ± 0.30a
Muscat Hambourg	Medium	Round	Dark red-violet	Very sweet	14.66 ±0.02d	2.62 ± 0.11c

Any two means in a column followed by same letters are not significant at ($p \leq 0.05$), NS = not significant, n = three replicates

Table 4. Biochemical characteristics of grape varieties grown under arid subtropical climate of Pakistan.

Varieties	Total soluble solids (%)	Titratable acidity (%)	TSS/TA ratio	pH	Ascorbic acid contents (VIT C, mg 100 g^{-1})
Kishmish	10.30 ± 0.30f	0.80 ± 0.02f	12.78 ± 0.57gh	4.85 ± 0.01bc	23.82 ± 0.99b
FlameTokay	19 .10 ± 0.10a	1.36 ± 0.01a	14.04 ±0.09g	4.83 ±0.01d	23.80 ± 1.01b
NARC-Black	15.06 ± 0.06de	0.47 ±0.01i	32.06 ± 0.70b	4.55 ± 0.01i	28.57 ± 2.01a
King Ruby	18.03 ± 0.05b	0.43 ± 0.02j	41.99 ± 1.84a	4.62 ± 0.02h	23.85 ± 0.05b
Sultania- C	14.33 ± 1.52e	1.17 ± 0.01b	12.26 ± 1.38h	4.67 ± 0.01g	23.79 ± 2.52b
Red Globe	15.60 ± 0.10d	0.66 ± 0.01h	23.64 ± 0.31c	4.81 ±0.01 e	19.19 ± 1.21d
Early White	16.60 ± 0.10c	0.83 ± 0.02e	20.00 ± 0.36de	4.86 ±0.01b	28.47 ± 0.23a
Thomson Seedless	18.00 ± 0.50b	0.87 ± 0.01d	20.69 ± 0.51d	4.43 ± 0.01j	19.00 ± 2.00d
Haita	15.60 ± 0.01d	0.82 ± 0.02ef	19.03 ± 0.53e	5.12 ± 0.02a	14.29 ± 1.01e
Gola	15.00 ± 0.10de	0.73 ± 0.01g	20.55 ±0.37d	4.76 ± 0.02f	24.27 ±0.64b
Muscat Hambourg	18.40 ± 0.20ab	1.08 ± 0.02c	17.04 ± 0.27f	4.84 ± 0.01cd	22.60 ± 1.44ac

Any two means in a column followed by same letters are not significant at ($p \leq 0.05$), NS = not significant, n = three replicates

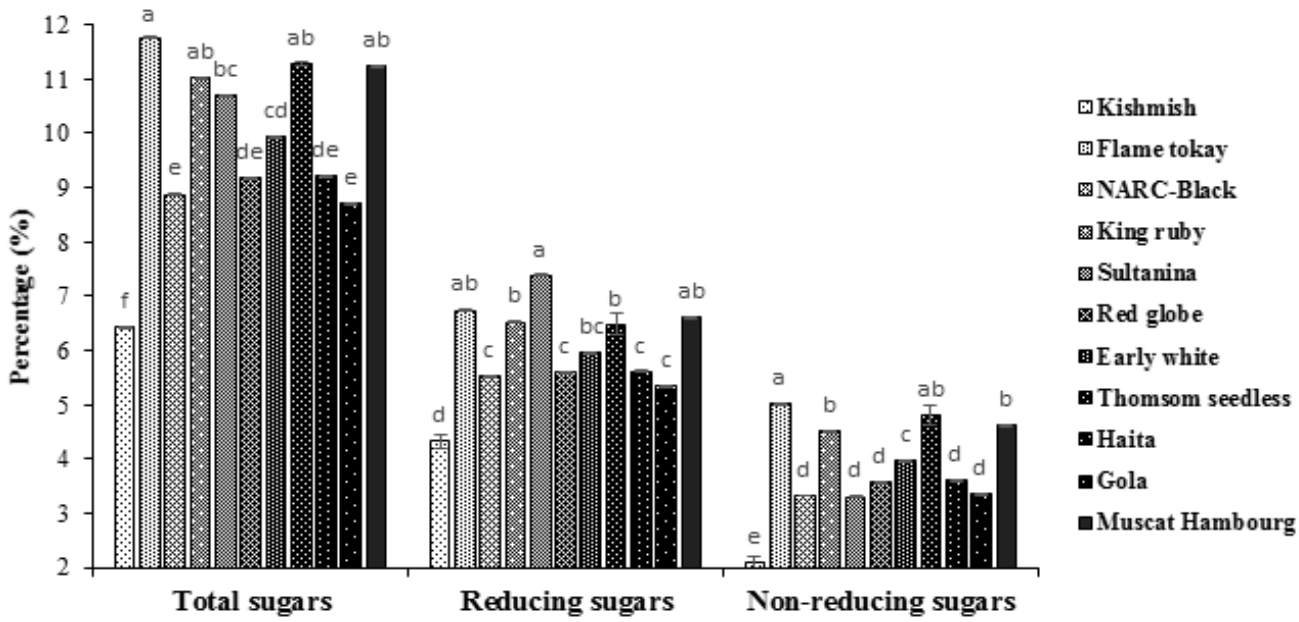

Fig. 3. Different level of sugars percentage in grape varieties grown under arid subtropical climate of Pakistan.

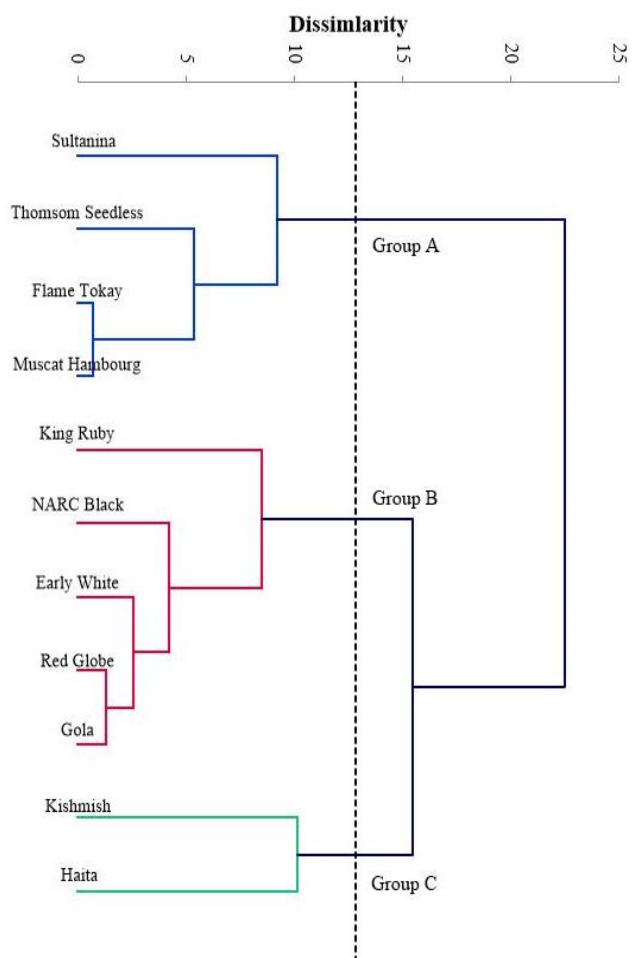

Fig. 4. Dendrogram on the base of biochemical attributes showing relation between genotypes grown under arid subtropical climate of Pakistan.

The dendrogram was developed on the base of fruit biochemical traits recorded in the study (Fig. 4). On the basis of biochemical attributes, it divided the genotypes in to three main groups. In Group A, there were only three exotic cultivars (Sultanina, Thomson Seedless, Flame Tokay and Muscat Hambourg) which have maximum resemblance with in group on the base of biochemical characteristics and have least resemblance with others Groups B and C. In Group B, there were total five genotypes, two were of local cultivars of Pakistan (Gola and NARC Black) which showed resemblance with three exotic cultivars (King Ruby, Early White and Red Globe). However, in Group C, there were only two local cultivars of Pakistan (Haita and Kishmish) which has resemblance with each other on the base of biochemical characteristics but were dissimilar from other groups.

Discussion

Monsoon rains are considered as a severe problem in most of the horticultural crops particularly fruit crops maturing in summer (monsoon season). In Pakistan monsoon season starts from first week of July and remains up to September. This season increases the humidity level and invites several fungal diseases. In grapes, it causes berry rotting and fungal diseases. In the present study, grapes cultivars Flame Tokay, NARC-Black, King Ruby and Early White matured earlier in June before monsoon season. The monsoon season in Punjab mostly started from 1st week of July or pre-monsoon rains may start in the last week of June which causes berry rotting, splitting and invitation to fungal diseases. As Chakwal is a dry arid sub-mountainous area having subtropical climate so temperature of this area increases early which ripens the grapes berries earlier as compared to cool and temperate regions. Further, early maturity of grapes is affected with climate, environment, soil and its own varietal character. Similar results were reported by (Flora, 1977) who reported that harvesting date of black, red and green color depends upon climatic conditions, geographical location of cultivar and it also depends upon variety character.

All the varieties grown under arid subtropical climate of Pakistan showed significant variations in bunch and berry characters. The maximum bunch length was observed in local cultivar Gola and Sultania-C which is among one of the most cultivated cultivar. Similarly, maximum number of berries were observed in Thomson seedless. It is one of the most preferred cultivated cultivar in the world especially for raisins due to small size and green in color. Kishmish, Red Globe and Thomson Seedless showed highest bunch compactness which indirectly invites to fungal diseases. In dense and compact varieties, berry decay or bunch rot is observed more compared to loose bunch varieties. In compact bunches, when berries split due to pressure or injury and juice oozes out of berry. It contains high amount of sugars and tritrable acidititiy which provides ideal temperature for fungus growth (*Botrytis cinerea*) in humid conditions after rainfall (Pscheidt, 2007). In our finding Kishmish and Thomson Seedless have very dense bunch and both are green color varieties. Commonly black cultivars have normal to loose bunches while green to light green varieties have compact bunches (Jackson and Lombard, 1993). Similar findings were observed by researches Khan *et al*., (2011) and Uddin *et al*., (2011) who evaluated different grapes varieties in different agro climatic zones of Punjab. Presence of good color is an indication of high antioxidant contents in grapes. Under Arid Subtropical Climate of Pakistan NARC- Black grapes were black, Flame Tokay produced purple red color, Muscat Hambourg produced Dark red-violet color, King Ruby and Red globe were Red-grey which was the normal varietal character of these cultivars. Similarly, Kishmish, Early White, Thomson Seedless, Haita, Gola exhibited their normal green-yellow color which showed all cultivars were rich in antioxidants as they produced their varietal normal color. Khan *et al*., (2011) also reported the similar findings that varieties which possessed their normal varietal color under warmer subtropical conditions showed normal content of antioxidants. Uddin *et al*., (2011) evaluated local and exotic grapes germplasm and found normal varietal color had attraction and was favored by consumer for its taste.

Organoleptic evaluation of these varieties was also conducted. All cultivars grown were good in taste. Local cultivars Early White, Haita, Gola and one exotic cultivar Muscat Hambourg were very sweet in taste while all remaining cultivars were sweet in taste. Whereas none of the acidic cultivar is evaluated. Guelfat-Reich and Safran, (1971) characterized the European grapes on the base of quality: (a) sweet (b) less sweet and (c) acidic and on the harvesting times. Kingston and Van Epenhuijsen, (1989) found that the cultivar Italia showed variable response on ripening under different environmental conditions.

The characteristics berry size, berry weight and berry diameter are correlated with each other. In all three parameters Gola variety attain maximum berry size, weight and diameter while the variety Thomson seedless show least berry size, weight and diameter under the agro climatic conditions of Chakwal. These results were in consonance with several grapes researchers (Fahmi *et al*., 2012; Mahmoud *et al*., 2009; Uddin *et al*., 2011). Attia and Farag, (2017) found increase in berry volume and size under the result of preharvest treatments of grapes.

TSS, TA and TSS:TA ratio are broadly accepted parameters which are used as grapes maturity indicators (Zoecklein, 2001). It is generally observed in our findings that small to mediums berry size cultivars like have more amount of TSS as compared to large to very large size. TSS observed in the cultivars grown under Arid Subtropical Climate of Pakistan was in ranged of 19.10 to 10.30%. These results were agreed with Fahmi *et al*., (2012) who evaluated the TSS of different grapes cultivars in 12 to 25% range and Aponso *et al*., (2017) who found TSS from 11.33 to 19.83% in comparison of different varieties. Similarly, titratable acidity has a significant effect on the organoleptic qualities, increased in TA creates tart in berries (Acar, 1999). The TA values of the studied varieties were ranged between 0.43% to 1.36%. The results are in symmetry with Johnson & Carroll, (1973) who declared 1.24% TA in grapes juice.

TSS: TA ratio was also significantly different in these grapes. It was in range of 12.26 to 41.99 %. TSS: TA ratio parameter is used as a quality parameter to several fruits including grapes (Flora, 1977). This result obtained was in range with Crisosto (2002) who declared TSS/TA near to 20 for grapes harvesting. The value mentioned is defined the lowest value for customer choice (Jayasena & Cameron, 2009). Du Plessis, (1977) explained that TSS/TA ratio is sign of grape ripeness as concentration of sugars and organic acids under similar conditions varies from one year to next. However, the differences in acidity and TSS: TA ratio may arises in grapes field due to varieties, environmental conditions, storage period and other factors (Diakou *et al*., 1997; Fahmi *et al*., 2012; Liu *et al*., 2006; Navarro *et al*., 2001).

The grapes pH is also considered an important factor for flavor and resistance to spoilage (Amerine, 1965). In our finding grapes pH was ranged between 4.43 to 5.12. These results are harmony with scientists Fahmi *et al*., (2012) & Soltekin *et al*., (2015) who evaluated grapes different cultivars and found pH of most varieties above 4. Tang, (1978) also observed changes in pH concentration during working on French, European, American and French varieties.

Vitamin C contents vary in fruits with exposure to sunlight and growing conditions (Franke *et al*., 2004). In our findings, ascorbic acid contents were maximum in NARC-Black (28.57 mg 100 g^{-1}) and Early White cultivars (28.47 mg 100 g^{-1}) which are also the early mature cultivars while the lowest ascorbic acid content was in Thomson Seedless (19 mg 100 g^{-1}) which is late mature cultivar. These results were resembled with the findings of Combs Jr and McClung, (2016) who observed maximum Vitamin C contents in early mature varieties as compared to late mature varieties. Our findings were similar with Ghorbani *et al*., (2017) who found decrease in ascorbic acid contents with time extension. Ascorbic acid and pH are inversely proportional to each other. Haita cultivar showed maximum pH (5.12) with least ascorbic acid contents (14.29 mg 100 g^{-1}) whereas NARC-Black showed minimum pH (4.55) with largest VIT C contents (28.57 mg 100 g^{-1}).

In our results, maximum total sugars were present in exotic cultivars Flame Tokay and Thomson Seedless. While minimum total sugars were observed in our local cultivar Kishmish. Eyduran *et al*., (2015) also reported the similar results and found maximum sugar contents in Thompson Seedless as compared to other varieties from Turkey. Our results were also in harmony with Khan *et al*., (2011) who found total sugars value range 11.44 to 13.60% during grapes cultivars evaluation grown under agro climatic condition of Faisalabad. It is generally observed that cultivars having more TSS have more amount of sugars in them as TSS is used as a sugar indicator parameter. This result was also confirmed by other researchers Muñoz-Robredo *et al*., (2011) & Shiraishi *et al*., (2010) who used TSS as sugar harvesting parameter for grapes maturity. Munoz-Robredo *et al*., (2011) & Tang, (1978) also observed changes in sugars values during characterization of grapes cultivars.

Yinshan *et al*., (2017) reported that sugars and acids of grapes are greatly influenced by cultural practices, soil topography, climatic as well as by environmental conditions. There is great variation occur in different regions which is called the interaction of genotype and environment. So, it is desirable to find out the variation and changes in sugars and organic acids of varieties grown in the same region. De Orduna, (2010) found large difference between the grapes harvested from cool regions compared to warm regions. Under warm climate grapes cultivars mature earlier and acid reserves convert to sugars earlier compared to temperate regions so growers have to wait less to get early crop. Earlier mature cultivars of grapes can be successfully cultivated in arid subtropical climate of (Chakwal) Pakistan as it matures before monsoon rains and escapes berries from risk of being damaged at high temperature. Moreover, it is essential to evaluate suitable exotic germplasm or cultivar for local environmental conditions (Khan *et al*., 2011). The taste and flavor of grapes are always influenced by climatic conditions, soil topography and cultural practices used at a particular area (Deloire, 2005). Normally soil, climate and cultivar are considered the main components which develops the particular taste and flavor in grapes (Liu *et al*., 2006).

Conclusion

On the basis of phenological attributes it is concluded that Flame Tokay, NARC- Black, King Ruby and Early white are early maturing cultivars and can be successfully grown under Arid Subtropical region of Pakistan. The biochemical characteristics of sugars like TSS, TS, RS and NRS observed more in exotic cultivars as compared to local cultivars. Whereas, maximum bunch length, bunch width, bunch weight, berry diameter and berry weight was observed more in local cultivars as compared to exotic cultivars under study. All other phenological, physical and biochemical studied in experiment were also helpful for future breeding.

Acknowledgement

The authors are grateful to the Barani Agricultural Research Institute (BARI), Punjab-Pakistan for provision of research material especially to Mr. Aqeel Feroz for his guideline during the research work.

References

Acar, J., N. Alper and O. Esturk. 1999. The production of cloudy apple nectar using total liquefaction enzymes. *Fruit Process*., 8: 314-317.

Ahmed, W., M. Junaid, M. Nafees, M. Farooq and B.A. Saleem. 2004. Effect of pruning severity on growth behavior of spur and bunch morphology of grapes (*Vitis vinifera* L.) Cv. Perlette. *Int. J. Agric. Biol*., 6(1): 160-161.

Amerine, M.A. 1973. Laboratory Procedures for Enologists. Association of Students Store, University of California, Davis, California.

Anonymous. 2014-15. Agriculture Statistics of Pakistan. Ministry of Food Agriculture Livestock, Islamabad, Pakistan.

Aponso, M.M.W., R.A.U.J. Marapana and R. Manawaduge. 2017. Physicochemical analysis of grape juice from Israel blue (Vitis vinifera L.) grape cultivar under different processing conditions and a comparison with Red Globe and Michele Palieri grape varieties. *J Pharmacogn Phytochem*., 6(3): 381-385.

Attia, S.M. and K.M. Farag. 2017. Effect of some preharvest treatments on the incidence of waterberry disorder and on fruit quality characteristics of "Thompson Seedless" table grapes. *American-Eurasian J. Agric. & Environ. Sci*., 17(5): 392-400.

Carey, V.A., D. Saayman, E. Archer, G. Barbeau and M. Wallace. 2008a. Viticultural terroirs in Stellenbosch, South Africa. I. The identification of Natural Terroir Units. *Int. Sci. Vigne Vin*., 42(4): 169-183.

Carey, V.A., E. Archer, G. Barbeau and D. Saayman. 2008b. Viticultural terroirs in Stellenbosch. South Africa. II. The interaction of Cabernet-Sauvignon and Sauvignon Blanc with environment. *Int. Sci. Vigne Vin*., 42(4): 185-201.

Combs, G.F. 2001. *The Vitamins, Fundamental Aspects in Nutrition and Health* (2nd ed.). San Diego, CA: Academic Press. p. 245-272. ISBN 978-0-12-183492-0.

Crisosto, H. 2002. Nuove tecnologie per ridurre I danni da Botryis cinerea nella conservazione dell´ uva da tavola. Rivista di Frutticoltura e di Ortofloricoltura. 64: 30-32.

Deloire, A., E. Vaudour, V. Carey, V. Bonnardot and C. Leeuwen. 2005. Grapevine responses to terrior: a global approach. *Int. Sci. Vigne Vin.*, 39(4): 149-162.

Diakou, P., A. Moing, L. Svanella, N. Ollat, D.B. Rolin, M. Gaudillere and J.P. Gaudillere. 1997. Biochemical comparison of two varieties differing in juice acidity. *Aust. J Grape Wine Res*., 3(3): 1-10.

Du Plessis, C.S. 1977. Grape components in relation to white wine quality. Proceedings of the International Symposium in the Quality of the Vintage, Cape Town, South Africa. p. 117-128.

Emese. J.N and P.F. Nagymate. 2008. The Stability of Vitamin C in Different Beverages. *Br Food J.,* 110(3): 296-309.

Eyduran, S.P., M. Akin, S. Ercisli, E. Eyduran and D. Maghradze. 2015. Sugars, organic acids, and phenolic compounds of ancient grape cultivars (*Vitis vinifera* L.) from lgdir province of Eastern Turkey. *Biol. Res*., 48: 2.

Fahmi, A.I., M.A. Nagaty and A.M.E. Shehawi. 2012. Fruit quality of Taif grape (*Vitis vinifera* L.) cultivars. *J. Am. Sci.,* 8: 590-599.

FAOSTAT. 2013. Food and Agricultural commodities production data. (Available online with updates at http://faostat.fao.org/ site/ 339/default.aspx).

Flora, L.F. 1977. Processing and quality characteristics of Muscadine grapes. *J. Food Sci*., 42: 935-940.

Franke, A.A., L.J. Custer, C. Arkaki and S.P. Murphy. 2004. Vitamin C and Flavonoid Levels of Fruits and Vegetables Consumed in Hawaii. *J. Food Compos. Anal*., 17: 1-35.

Ghorbani, B., Z. Pakkish and R. Najafzadeh. 2017. Shelf life improvement of grape (*Vitis vinifera* L. cv. Rish Baba) using nitric oxide (NO) during chilling damage. *Int. J Food Prop*., 20(3): 2750-2763.

Hegedus, A., R. Engel, L. Abranko, E. Balogh, A. Blazovics, R. Herman, J. Halasz, S. Ercisl, A. Pedryc and E.S. Banyai. 2010. Antioxidant and antiradical capacities in apricot (*Prunus armeniaca* L.) fruits: Variation from Genotypes, Years, and Analytical Methods. *J. Food Sci*., 75(9): 722-730.

Hunter, J.J and V. Bonnardot. 2011. Suitability of some climatic parameters for grapevine cultivation in South Africa, with focus on key physiological processes. *S. Afr. J. Enol. Vitic*., 32(1): 137-154.

Jackson, D.I and P.B. Lombard. 1993. Environment and management practices affecting grape composition and wine quality A Review. *American J. Enol. Viti.,* 4(44): 409-430.

Jayasena, V. and I. Cameron. 2009. The effect of ethephon and clone on physical characteristics and sensory quality of Crimson Seedless table grapes after 1 month storage. *IJFST.,* 44: 409-414.

Johnson, L.A. and D.E. Carroll. 1973. Organic acid and sugar contents of Scuppernong grapes during ripening. *J. Food Sci.,* 38: 21-24.

Jones, G.V. 2007. Climate Change: Observations, Projections, and General Implications for Viticulture and Wine Production. Practical Winery and Vineyard, July/August. p. 44-46.

Khan, A.S., A.U. Malik, M.A. Pervez, B.A. Saleem, I.A. Rajwana, T. Shaheen and R. Anwar. 2009. Foliar application of low-biuret urea and fruit canopy position in the tree influence the leaf nitrogen status and physico-chemical characteristics of kinnow mandarin (*Citrus reticulata blanco*). *Pakistan J. Bot*., 41(1): 73-85.

Khan, A.S., N. Ahmad, A.U. Malik, B.A. Saleem and I.A. Rajwana. 2011. Pheno-physiological revelation of grapes germplasm grown in Faisalabad, Pakistan. *Int. J. Agric. Biol.,* 13(5): 791-95.

Khan, W.A., T. Shafiq and M. Ahmed. 2008. Physical and biochemical changes in commonly grown grapes (*Vitis vinifera*) in Pakistan at different maturity levels. *Pak. J. of Sci.,* 60(3): 94-99.

Kingston, C.M and C.W. Van Epenhuijsen. 1989. Influence of leaf area on fruit development and quality of Italia glasshouse table grapes. *American J. Enol. Viti*., 40: 130-134.

Köse, B. 2014. Phenology and Ripening of *Vitis vinifera* L. and *Vitis labrusca* L.varieties in the maritime climate of samsun in Turkey's black sea region. *S. Afr. J. Enol. Vitic*., 35(1): 90-102.

Leeuwen, V.C., C. Friant, F. Friant, X. Chone, O. Tregoat, S. Koundouras and D. Dubourdieu. 2004. Influence of climate, soil and cultivar on terroir. *Am. J. Enol. Vitic*., 55(3): 207-217.

Liu, H.F., B.H. Wu, P.G. Fan and S.H. Li. 2006. Sugar and acid concentrations in 98 grape cultivars analyzed by principal component analysis. *J. Sci. Food Agr*., 86: 1526-1536.

Mullins, M.G., A. Bouquet and L.E. Williams. 1992. Biology of the grapevine. Cambridge University Press, Cambridge.

Muñoz-Robredo, P., P. Robledo, D. Manríquez, R. Molina and B. Defilipi. 2011. Characterization of sugars and organic acids in commercial varieties of table grapes. *Chil. J. Agr. Res*., 71: 453-458.

Navarro, M., J.J. Retamales and B. Defilippi. 2001. Efecto del arreglo de racimo y aplicacion de CPPU en la calidad de uva de mesa Sultanina tratada con dos fuentes de giberelinas. *Agricultura Tecnica*., 61(1): 15-21.

Nelson, K.E. 1985. Harvesting and handling California table grapes for market. Bulletin 1913. University of California Press, DANR Publications, Oakland, California, USA. p.72.

Nemani, R.R., M.A. White, D.R. Cayan, G.V. Jones, S.W. Running, J.C. Coughlan and D.L. Peterson. 2001. Asymmetric warming over coastal California and its impact on the premium wine industry. *Climate Res*., 19: 25-34.

Orduna, M.R. 2010. Climate change associated effects on grape and wine quality and production. *Food Res. Int*., 43: 1844-1855.

Prado, D.A.D.R., R.M. Yuste, X. Sort, L.C. Andres, M. Torres and R.M.L. Raventos. 2007. Effect of soil type on wines produced from *Vitis vinifera* L. cv. Grenache in commercial vineyards. *J. Agric. Food Chem*., 55(3): 779-786.

Pscheidt, J. 2007. Grape-Botrytis bunch rot, Oregon State University Extension, Available at: http://plantdisease.ippc.orst.edu/disease.cfm?RecordID=514.00000.

Ramos, A.M., N. Lorenzo, J. Taboada and J. Lorenzo. 2013. Influence of climate variability on grape production and wine quality in the Rias Baixas, north-western Spain. EGU General Assembly Conference. *Abstracts.,* 15: 3011.

Reich, G.S. and B. Safran. 1971. Indices of Maturity for Table Grapes as Determined by Variety. *AJEV*., 22: 13-18.

Robredo, P.M., P. Robledo, D. Manriquez, R. Molina and B.G. Defilippi. 2011. Characterization of sugars and organic acids in commercial varieties of table grapes. *Chil. J. Agr. Res*., 71(3): 452-458.

Ruck, J.A., 1969. Chemical Methods for Analysis of Fruit and Vegetables, pp: 27-30. Summerland Research Station, Department of Agriculture, Canada SP50.

Sabry, G.H.M., M.S. Rizk-Alla and S.Y. Mohamed. 2009. Horticultural and molecular genetics characterization of some grape cultivars under desert land conditions. *J. Biol. Chem. Environ. Sci.,* 7(4): 519-544.

Shiraishi, M., H. Fujishima and H. Chijiwa. 2010. Evaluation of table grape genetic resources for sugar, organic acid, and amino acid composition of berries. *Euphytica*., 174: 1-13.

Soltekin, O., T. Teker, A. Erdem, E. Kacar and A. Altindis. 2015. Response of "Red Globe" (*Vitis vinifera* L.) to cane girdling. *BIO Web of Conferences*., 5: 1-4.

Tang, F.C. 1978. Chemical analysis of grape varieties grown in Lubbock Texas. M.Sc. Thesis, Texas Tech University, Texas terroir, a global approach. *J. Int. Vigne. Vin.,* 39(4): 149-162.

Uddin, M., M. Shah, K.U. Rahman, R. Alam and M.A. Rauf. 2011. Evaluation of local and exotic grapes germplasm at Mingora, Swat. *Sarhad J. Agric*., 27(4): 553-556.

Yinshan, G., N. Zaozhu, S. Kai, Z. Jia, R. Zhihua, Z. Yuhui, G. Quan, G. Hongyan and G. Xiuwu. 2017. Composition and content analysis of sugars and organic acids for 45 grape cultivars from northeast region of China. *Pak. J. Bot.,* 49(1): 155-160.

Zamora, F. 2003. Elaboraciony Crianza Del Vino Tinto: Aspectos Cientificosy Practicos. AMV ediciones y Mundi-Prensa. Madrid.

Zoecklein, B.W. 2001. Grape sampling and maturity evaluation for growers. *Vintner's Corner.,* 16: 1-6.

(Received for publication 11 October 2018)