UDC 575
https://doi.org/10.2298/GENSR1802483A
Original scientific paper

GENETIC DIVERSITY OF JUJUBE (*Ziziphus mauritiana*) CULTIVARS

Wajeeha AMIN[1], Sajjad HUSSAIN[1], Muhammad Akbar ANJUM[1], Shaghef EJAZ[1], Muhammad SAQIB[1] , Muhammad Fasih KHALID[1], Sezai ERCISLI[2*], Shakeel AHMAD[3]

[1]Department of Horticulture, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University, Multan, Pakistan
[2]Department of Horticulture, Faculty of Agriculture, Ataturk University, Erzurum, Turkey
[3]Department of Agronomy, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University, Multan, Pakistan

Amin W., S. Hussain, M. Akbar Anjum, S.Ejaz, Muhammad Saqib, M. Fasih Khalid , S. Ercisli, S. Ahmad (2018): *Genetic diversity of jujube (Ziziphus mauritiana) cultivars).*- Genetika, Vol 50, No.2, 483-494.

The present study was conducted on five jujube (*Ziziphus mauritiana* Lamk.) cultivars (Anokhi, Karela, Dill bahar, Ajooba and Dehli white) grown in two locations in Punjab, Pakistan during seasons 2014-2015 and 2015-2016. The aim of the study was to determine genetic diversity based on fruit properties fruit (weight, length, diameter), seed (weight, length, diameter), pulp weight, juice pH, total soluble solids (TSS), titratable acidity (TA), vitamin C, sugars (total, reducing, and non-reducing), antioxidant capacity and total phenolics. All cultivars significantly differed from each other in their fruit physico-chemical attributes. Dehli white cultivar had the highest fruit weight (22.90 g), fruit diameter (37.58 mm), pulp weight (16.83 g) and seed diameter (10.33 mm) than other cultivars. Dill bahar had the highest fruit length (43.75 mm), seed weight (2.69 g), juice pH (4.98), vitamin C content (55.86 mg/100 mL juice) and total phenolic contents (146.98 µg GAE per mL). Anokhi had the highest seed length (26.13 mm), non-reducing sugars (37.81%), total sugars (47.23%) and antioxidant capacity (1016.8 mM trolox per 100 mL). In Bahawalpur and Faisalabad's environmental conditions Dehli white and Dill bahar cultivars were with better physical properties. However, according to biochemical properties Ajooba and Anokhi cultivars were better in Bahawalpur.

Key words: Environmental conditions, Fruit characteristics, Locations, *Z. mauritiana*

Corresponding author: Sezai Ercisli, Ataturk University Agricultural Faculty Department of Horticulture 25240 Erzurum-Turkey, Phone: 090 4422312599, Fax: 090 4422360958, e-mail: sercisli@gmail.com

INTRODUCTION

Jujube (*Ziziphus mauritiana* Lamk) is also well-known as Chinese apple, ber and Indian jujube belongs to genus *Ziziphus* and a buckthorn family Rahmnaceae (SHARMA and GUAR, 2013) and distributed between the latitudes of 34° south and 51° north in tropical and subtropical areas of the world and at altitude up to 2800 meters above sea level. *Z. mauritiana* occurs in almost every region of the world and native to Afghanistan, Australia, North Africa, North India, Malaysia, and southern China. In India and Pakistan, *Z. mauritiana* is a prevailing component of natural vegetation in deserts along with a great example of extremely drought-hardy species (KAMILOGLU *et al*., 2009; RAZI *et al*., 2013).

In Pakistan, it is widely distributed in three provinces i.e. Khyber paktunkhwa (Banuu, Karak and Kohat districts), Punjab (Attock, Chakwal and Mianwali districts) and Sindh province (Karachi, Hyderabad and Nawabshah districts). In Pakistan, jujube is cultivated on an area about5.425 ha with an annual production of 28.000 tones (QAMER *et al*., 2007).

Z. mauritiana is an evergreen species and drought resistant in nature (CHERRY, 1985). It can also be grown magnificently in saline soil (MEENA *et al*., 2003). Different environmental aspects such as rainfall, temperature, light and wind cause fruit loss. Fruit quality during fruit growth and fruit ripening stage is affected by temperature (ARPAIA, 1994). Jujube requires little rainfall and tolerates a wide range of temperature which varies from -5°C to 49°C. However, *Z. mauritiana* does not tolerate frost (VON CARLOWITZ *et al*., 1991).

The fruit physico-chemical characteristics quite variable among cultivars, which varied from 3.8 to 39.5 g in fruit weight, from 18.2 to 58.0 mm in fruit lenght, from 11 to 47 mm in fruit diameter and pulp yield from 81 to 97% (CHOVATIA *et al*., 1993; JAWANDA and BAL, 1981; GHOSH and MATHEW, 2002). Nutritionally the pulp of jujube fruits comprises total soluble solids (12–23%), titratable acidity (0.13-1.42%), total sugars (3.1-14.5%), reducing sugars (1.4-9.7%), sucrose (5.6%), glucose (1.5%), fructose (2.1%) and starch (1.0%) (BAL, 1990; GHOSH and MATHEW, 2002). It is also a rich source of vitamin C. JAWANDA and BAL, (1978) stated that, ascorbic acid content ranged from 39-166 mg/100 g of fruit pulp in different jujube cultivars.

There is lack of information regarding jujube cultivars in Pakistan. Indigenous cultivars are missing and there is little research work available on their botanical classification (RAZI *et al*., 2013). Fluctuation in yield and quality of jujube fruit is greatly affected by the soil properties, climatic factors and cultivar selection (GAO *et al*., 2011). Fruit quality attributes largely depend upon cultivar to be selected. Previously, variations in fruit weight (REICH, 1991), juice content (COLLADO-GONZALEZ *et al*., 2013) and seed weight (ECEVIT *et al*., 2007) have been recorded in jujube cultivars.

Jujube fruit quality in terms of nutritive value and phytochemical compounds is gaining importance and quality is affected by environment (ARPAIA, 1994), cultivars (GAO *et al*., 2011), and water availability (KUMAR, 2012). Therefore, the present study was conducted to assess the variation in physico-chemical characteristics of promising jujube (*Ziziphus mauritiana*) cultivars grown under different agro-climatic conditions in Faisalabad and Bahawalpur, Pakistan.

MATERIALS AND METHODS

Plant material

The current study was conducted to evaluate the physico-chemical characters of five jujube (*Ziziphus mauritiana*) cultivars in postgraduate laboratory of Department of Horticulture, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University, Multan,

Pakistan during 2015-2016. The cultivars were Anokhi, Karela, Dill bahar, Ajooba and Dehli white. The age of trees were between 15-20 years and selected from fruit orchards of Horticultural Research Institute AARI, Faisalabad, Punjab (31.4310° N, & 73.0695° E, 183 m altitude) and Horticultural Research Station Bahawalpur, Punjab (71.3866 °E & 29.2272 °N, 100.28 m altitude) (Table 1). Cultural and management practices were adopted for the trees. Climate of both locations falls in arid to semi-arid range. Data for temperature and rainfall pattern for both locations are given in Figure 1.

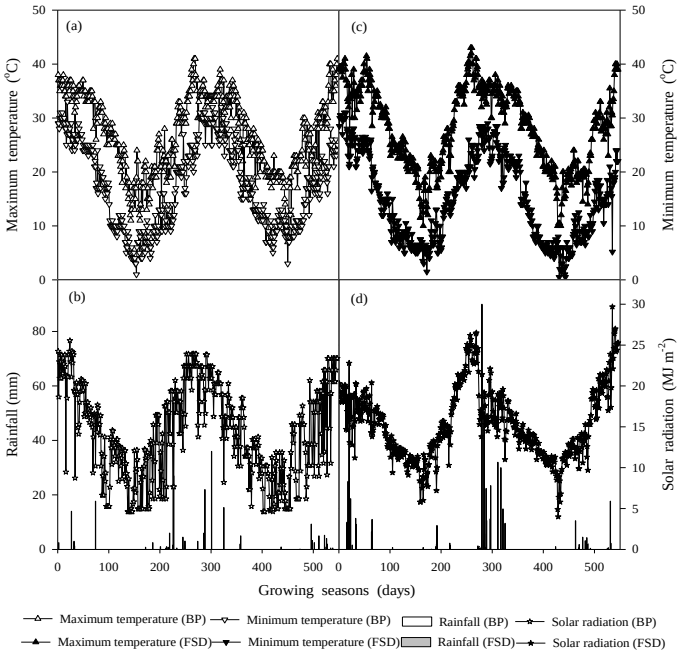

Figure 1. Daily maximum and minimum temperatures (a, c), rainfall and solar radiation (b, d) at Bahawalpur (a, b; unfilled symbols) and Faisalabad (c, d; filled symbols) during both seasons.

Table 1. Geographical and meteorological data of Bahawalpur and Faisalabad location

Location	Bahawalpur	Faisalabad
Latitude	29.2272 °N	31.4310° N
Longitude	71.3866 °E	73.0695° E
Altitude (m)	100.28	183
Mean maximum temperature °C	35.6	33
Mean minimum temperature °C	13.4	11.5
Average rainfall (mm)	143	300

Methods

For each cultivar, three trees were selected randomly for fruit collection. Each cultivar was considered as a treatment and each tree as a replication. For measuring physico-chemical attributes, a randomly sample of 10 fruits was harvested from each selected tree. Fruits were harvested at the start of March when the specific gravity of the fruit reaches below 1.00. Fruit length, weight and diameter were determined through digital vernier caliper (IKKEGOL).

Average fruit weight was determined using electronic weighing balance (WT6002-D). Fruits were peeled and seeds were removed to measure pulp weight and seed weight separately. For chemical analysis 10 fruits were randomly selected from each treatment unit. These fruits were washed and dried at room temperature and electrical juicer was used to extract the juice. Juice weight of ten fruits was taken with the help of weighing balance. Juice pH was recorded using pH meter (MI 180, Hungary). For determining total soluble solids (TSS), digital refractometer (PAL-1, Atago, Japan) was used. Titratable acidity was determined through titration with NaoH and expressed as %. Vitamin C content was determined through Indophenol's titration method as developed by RUCK (1963). Sugars (reducing, non-reducing and total) were determined by following the procedure of HORTWITZ (1960). Trolox equivalent antioxidant capacity (TEAC) and total phenolic contents were determined by following the modified method of OZGEN *et al.*, (2010).

Statistical analysis

The experiment was a completely randomized design. Data were subjected to analysis of variance and means were separated by Duncan multiple range test at $P<0.01$ significant level (SAS, 2005).

RESULTS AND DISCUSSION

The two year data regarding physico-chemical analysis of jujube cultivars were statistically analyzed. Initially year was considered as a factor. However, the most parameters were not significantly affected by the year. Therefore, the data of both years were pooled together and then analysis of variance was performed and LSD values of five cultivars and locations are shown in Table 2.

Table 2. Analysis of variance and LSD values of five Ber varieties grown in two different agro-climatic conditions

Parameter	Variety	Location	Variety × location
Fruit weight (g)	0.6706 **	0.4241 **	0.9483 **
Fruit diameter (mm)	1.2667 **	0.8011 **	1.7913 **
Fruit length (mm)	1.1360 **	0.7185 **	1.6066 **
Seed weight (g)	0.0970 **	0.1534 **	0.2170 **
Seed length (mm)	0.6939 **	0.4388 **	0.9813 **
Seed diameter (mm)	0.2996 **	0.1895 **	0.4237 *
Fruit juice (%)	3.2337 **	2.0452 **	4.5731 **
Fruit Juice (pH)	0.1805 ns	0.1142 **	0.2553 *
Titratable acidity (%)	0.0380 *	0.0240 **	0.0537 *
TSS (° Brix)	0.2426 **	0.1534 **	0.3431 **
Pulp weight (g)	0.4525 **	0.2862 **	0.6399 **
Vitamin-C (mg/100 ml juice)	1.6369 **	1.0352 **	2.3149 **
Total sugars (%)	1.2052 **	0.7622 *	1.7044 **
Reducing sugars (%)	0.2014 **	0.1274 *	0.2848 **
Non-reducing sugars (%)	1.1959 **	0.7564 ns	1.6913 **
Total phenolics (µg/GE ml)	4.8635 **	3.0759 **	6.8780 **
Antioxidant capacity (mM trolox/ 100 ml)	141.47 *	89.472 ns	200.07 **
Antioxidant activity (%)	3.6138 *	2.2856 ns	5.1107 **

Physical attributes

Physical characteristics were significantly affected by the interactive effect of cultivars and locations. The maximum fruit weight was recorded in cultivar Dehli white at Faisalabad location (22.90 g) followed by Dill bahar at Bahawalpur location (22.40 g) (Figure 2A). Regarding fruit diameter, Dehli white showed maximum value at Bahawalpur (37.58 mm), followed by Dill bahar at Bahawalpur (34.37 mm) and Dehli white at Faisalabad (34.13 mm). The two parameters were significantly differed between cultivars and locations (Figure 2B). Fruit length was maximum in Dill bahar at Bahawalpur (43.75 mm), followed by Karela at Bahawalpur (43.32 mm) and Karela at Faisalabad (42.16 mm). Fruit length were significantly differed between cultivars and locations (Figure 2C). Concerning seed characteristics of the jujube cultivars, the maximum seed weight was recorded in Dill bahar at Bahawalpur (2.69 g), followed by Anokhi at Bahawalpur (2.09 g) and Dehli white harvested from Bahawalpur (2.09 g) (Figure 2D). The seed length was found maximum in Anokhi at Bahawalpur (26.13 mm), followed by Karela at Bahawalpur (24.03 mm) and Anokhi at Faisalabad (24.01 mm). The two parameters were statistically significantly differed between cultivars and locations (Figure 2E). The maximum seed diameter was observed at Bahawalpur location in Dehli white (10.33 mm) followed by Dill bahar (10.12 mm) and Ajooba (10.12 mm). These three cultivars were statistically similar with each other (Figure 2F).

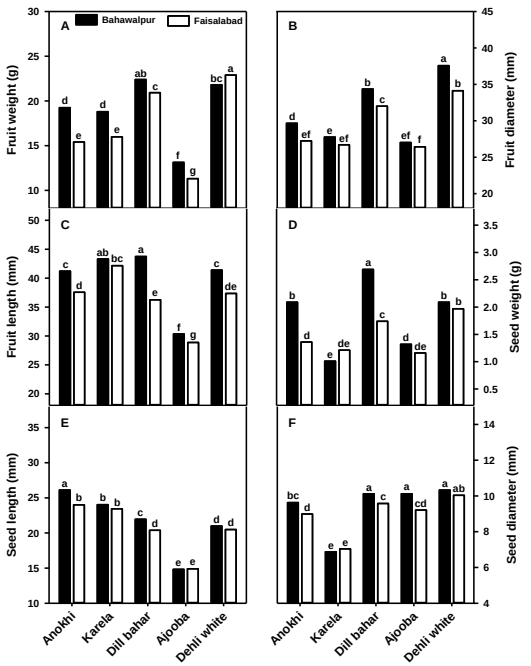

Figure 2. A) fruit weight, B) fruit diameter, C) fruit length, D) seed weight, E) seed length, F) seed diameter of five Ber varieties (Anokhi, Karela, Dill bahar, Ajooba and Delhi white) grown in two different agro-climatic conditions (Bahawalpur and Faisalbad). N=20

In the current study physical characteristics of jujube fruit varied among cultivars and our findings are in accordance with GAO *et al*. (2011) who also reported that cultivar is the main factor affecting fruit physical characteristics in jujube. GODI *et al*., (2016) also obsreved significant differences among the physical attributes of jujube genotypes. These attributes depends upon various genetic factors (DHUIQUE-MAYER *et al* ., 2009; FANCIULLINO *et al*., 2006; GOLDENBERG *et al*., 2014). In addition with genetics, different environmental aspects such as rainfall, temperature, light also influence physico-chemical attributes (SHELLIE and MANGAN, 1994; ISHFAQ *et al*., 1999).

In our study, physical parameters were also affected by the locations. The same cultivars at two different locations exhibited significant differences in fruit characteristics. Fruit weight was maximal at Faisalabad location and other parameters viz. fruit length and width, seed weight, length and diameter were maximal at Bahawalpur location. This might be due to the environmental factors, which varied between locations.as seen in Figure 1, the average of maximum temperature is higher at Bahawalpur location than Faisalabad. Regarding rainfall pattern, intensity as well as frequency was higher at Faisalabad location as compared with Bahawalpur. Solar radiation has a great influence on fruit physical as well as chemical properties. In Bahawalpur location average solar radiation was low than Faisalabad and WASEEM *et al.,* (2002) also reported that light conditions can affect fruit physical characteristics.

Biochemical characteristics

The juice percentage was found maximum in fruits of Ajooba cultivar at Faisalabad location (44.28%), followed by Dehli white at Bahawalpur (41.76%) and Karela at Faisalabad (38.23%). This parameter was significantly differed both cultivars and locations (Figure 3A). Juice percentage varied among cultivars and also due to the environmental conditions. Our results are supported by MOHAR *et al*. (2011), NAWAZ *et al*. (2012) who concluded that juice percentage in jujube cultivars varied at different agro-climatic conditions. The jujube fruits showed maximum juice pH in Dill bahar at Faisalabad location (4.98), followed by Anokhi at Faisalabad (4.86) and Dehli white collected from Faisalabad (4.71). This parameter was significantly differed both cultivars and locations (Figure 3B). Juice titratable acidity was recorded maximum in Karela (0.52%) followed by the cultivar Ajooba (0.51%) and Dehli white (0.50%). This parameter was significantly differed between cultivars and locations (Figure 3C). Total soluble solids (TSS) was recorded maximum in cultivar Ajooba at Bahawalpur (13.58 ºBrix), followed by Karela at Bahawalpur (13.16ºBrix) and this patrameter was dissimilar with cultivar Anokhi at Faisalabad location (12.83ºBrix) as shown in Figure 3D. TSS depends on fruit maturity (GUNDUZ and SARACOGLU, 2014) and it is also affected by the cultivars (CHEN *et al*., 2006; GAO *et al*., 2003; JIANG *et al*., 2006). The maximum pulp weight was recorded in Dehli white at Faisalabad location (16.83 g) followed by Dill bahar at Bahawalpur (15.31 g) and Dehli white taken from Bahawalpur (15.24 g) (Figure 3E). Vitamin C content was found maximum in cultivar Dill bahar at Bahawalpur (55.86 mg/100 mL juice) followed by Ajooba at Bahawalpur (44.75 mg/100 mL juice) and Dill bahar at Faisalabad location (42.28 mg/100 mL juice). Vitamin C was significantly differed between cultivars and locations all these were statistically different from each other (Figure 3F). Jujube fruit is rich in vitamin C and in our study, it significantly varied among cultivars and locations. BERMEJO *et al*. (2011) also reported the effect of cultivars on various biochemical content in citrus cultivars.

Sugars (total, reducing and non-reducing) were significantly affected by jujube cultivars and also the locations. The total sugars were recorded maximum in cultivar Anokhi at Bahawalpur (47.23%), followed by Dill bahar at Faisalabad (43.45%) and Karela at Bahawalpur (43.18%) (Figure 4A). The maximum percentage of reducing sugars were found in cultivar Dehli white at Bahawalpur (8.09%), followed by Ajooba at Faisalabad (7.80%) and Ajooba at Bahawalpur (7.65%). This parameter was significantly differed between cultivars and locations (Figure 4b). Anokhi at Bahawalpur location produced maximum non-reducing sugars (37.81%), followed by cultivar Karela at Bahawalpur (35.61%) (Figure 4C). Our results elaborated that cultivars as well as locations influenced the different types of sugars in jujube. Similarly, HULME (1971) and MARSH *et al.,* (2000) concluded that organic acids and sugars are affected by the ecological conditions, management practices such as irrigation, rootstock, species as well as cultivar to be studied. Light conditions also affect acidity and sugars. Low light increases total sugars and reducing sugars in litchi fruits (WASEEM *et al*., 2002).

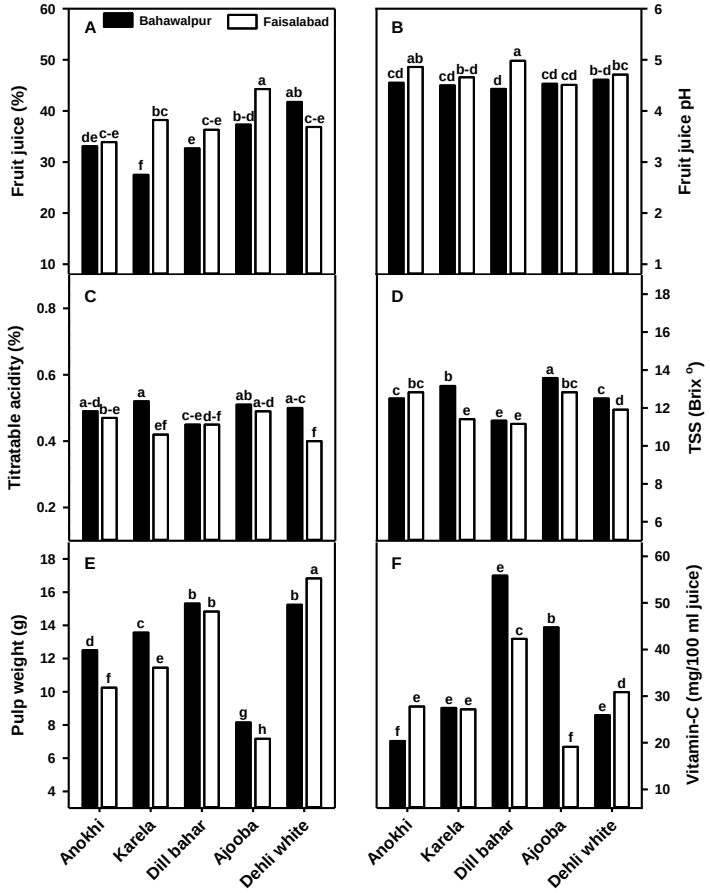

Figure 3. A) fruit juice, B) fruit juice pH, C) titratable acidity, D) TSS, E) pulp weight, F) vitamin-C of five Ber varieties (Anokhi, Karela, Dill bahar, Ajooba and Delhi white) grown in two different agro-climatic conditions (Bahawalpur and Faisalbad). N=20

Regarding total phenolic content, the maximum values were recorded in jujube cultivar Dill bahar at Bahawalpur location (146.98 µg GAE/mL), followed by Ajooba at Bahawalpur (142.77 µg GAE/mL) and Karela at Bahawalpur location (138.56 µg GAE/mL); this parameter was statistically significantly differed both cultivars and locations (Figure 4D). Our results indicated that total phenolic contents significantly varied among different jujube cultivars and also among locations. The important factors affecting total phenolic contents include climatic factors, cultivars and harvest stage (MOULY *et al*., 1997; RAPISARDA *et al*., 1998).

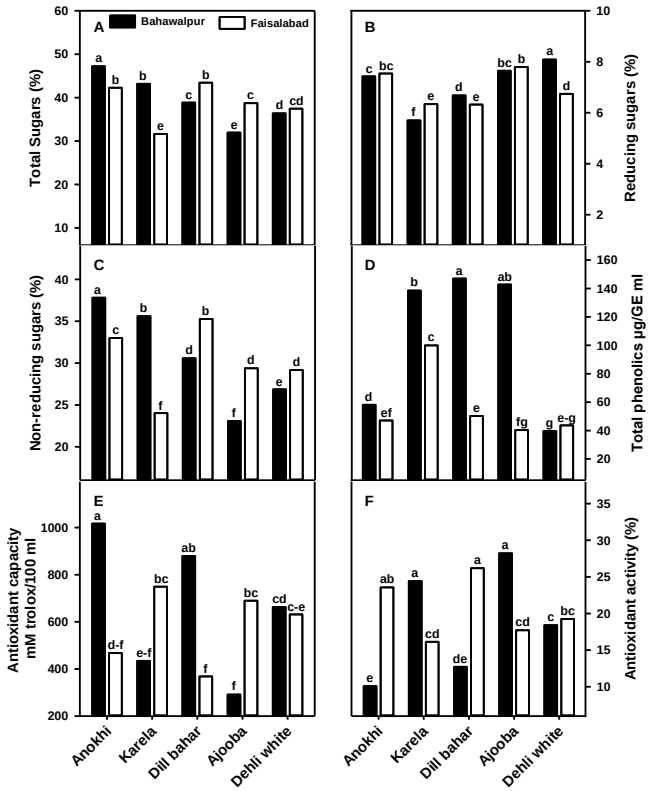

Figure 4. A) total sugars, B) reducing sugars, C) non-reducing sugars, D) total phenolics, E) antioxidant capacity, F) antioxidant activity of five Ber varieties (Anokhi, Karela, Dill bahar, Ajooba and Delhi white) grown in two different agro-climatic conditions (Bahawalpur and Faisalbad). N=20

Jujube cultivar Anokhi possessed the maximum antioxidant capacity when collected from Bahawalpur (1016.8 mM trolox/100 mL), followed by Dill bahar at Bahawalpur (879.2 mM trolox/100 mL) and Karela at Faisalabad location (749.3 mM trolox/100 mL) (Figure 4E). This parameter was statistically significantly differed both cultivars and locations (Figure 4F). Antioxidants activity is dependent on cultivar, climatic and edaphic factors, maturity stage and also postharvest treatments (KALT, 2005; OZGEN *et al*., 2008; CANAN *et al*., 2016; SARIDAS *et al*., 2016). ZOZIO *et al*., (2014) also observed the different antioxidants activity among jujube

cultivars. Antioxidant activity is also related with vitamin C content and total phenols (ZVAIGZNE *et al*., 2009). Cultivars, environmental conditions and fruit maturity are the factors that influence the phenolic profile (MOULY *et al*., 1997; RAPISARDA *et al*., 1998; ZORENC *et al*., 2016); therefore antioxidant profile varies accordingly. ZVAIGZNE *et al*., (2009) examined antioxidant activity of fruits the results showing that response of fruit juices towards antioxidant activity depends on vitamin C and total phenol content present in them. KALT (2005) and OZGEN *et al*., (2008) reported that antioxidant capacity is affected by variety, genotype and characteristics of fruit, maturity stage of fruit, growing conditions, postharvest duration and treatments of fruit.

CONCLUSION

Results of present research showed that all cultivars significantly differed with each other in their physico-chemical attributes. As concerning with the physical properties in Bahawalpur and Faisalabad's environmental conditions, Dehli white performed better than all others cultivars. However, among biochemical properties Ajooba and Anokhi performed better in Bahawalpur's environmental condition. Moreover, Dehli white was also better in overall acceptability.

Received, October 22nd, 2017
Accepted February 18th, 2018

REFERENCES

ARPAIA, M.L. (1994): Preharvest factors influencing postharvest quality of tropical and subtropical fruit. HortScience, *29* (9): 982-985.

BAL, J.S. (1990): Identification of ber (*Zizyphus mauritiana* Lamk.) cultivars through vegetative and fruit characters. Fruit Breeding and Genetics, *317*: 245-254.

BERMEJO, A., M. LLOSÁ, A. CANO (2011): Analysis of bioactive compounds in seven citrus cultivars. Food Sci. Tech., *56*: 6185-6205.

CANAN, I., M. GUNDOGDU, U. SEDAY, C.A. OLUK, Z. KARASAHIN, E.C. EROGLU, E. YAZICI, M. UNLU (2016): Determination of antioxidant, total phenolic, total carotenoid, lycopene, ascorbic acid, and sugar contents of Citrus species and mandarin hybrids. Turk. J. Agric. Forestry, *40*: 894-899.

CHEN, Y.Q., X.H. ZHONG, L.F. GAN (2006): The performance of Liuxiangzao jujube cultivar and its cultural techniques. South China Fruits, *1*: 49-50.

CHERRY, M. (1985): The Needs of the People. In: Wickens, G.E, Goodin, J.R & Field, D.V., (Eds.). Plants for Arid Lands. Unwin Hyman, London, UK.

CHOVATIA, R.S., D.S. PATEL, G.V. PATEL (1993): Performance of ber (*Zizyphus mauritiana* Lamk) cultivars under arid conditions. Annals of Arid Zone, *32*: 215-217.

COLLADO-GONZALEZ, J., Z.N. CRUZ, P. RODRIGUEZ, A. GALINDO, F.G. DIAZ-BANOS, J. GARCA DE LA TORRE, F. FERRERES, S. MEDINA, A. TORRECILLAS, A. GIL-IZQUIERDO (2013): Effect of water deficit and domestic storage on the procyanidin profile, size, and aggregation process in pear-jujube (*Ziziphus jujuba*) fruits. J. Agric. Food Chem., *61* (26): 6187-6197.

DHUIQUE-MAYER, C., A.L. FANCIULLINO, C. DUBOIS, P. OLLITRAULT (2009): Effect of genotype and environment on citrus juice carotenoid content. J. Agric. Food Chem., *57*(19): 9160-9168.

ECEVIT, F.M., B. SAN, T. DILMACUNAL, F.H. TURK, A.N. YILDIRIM, M. POLAT, F. YILDIRIM (2007): Selection of superior ber (*Ziziphus jujuba* L.) genotypes in civril region. J. Agric., *14* (1), 51-56.

FANCIULLINO, A.L., C. DHUIQUE-MAYER, F. LURO, J. CASANOVA, R. MORILLON, P. OLLITRAULT (2006): Carotenoid diversity in cultivated citrus is highly influenced by genetic factors. J. Agric. Food Chem., *54* (12): 4397-4406.

GAO, L., G.F. ZHOU, G.N. SHEN (2003): New jujube varieties and their cultural techniques. China Fruits, *2*: 38-40.

GAO, Q.H., P.T. WU, J.R. LIU, C.S. WU, J.W. PARRY, M. WANG (2011): Physico-chemical properties and antioxidant capacity of different jujube (*Ziziphus jujuba* Mill.) cultivars grown in loess plateau of China. Scientia Horticulturae, *130* (1):67-72.

GHOSH, S.N. and B. MATHEW (2002): Performance of nine ber (*Ziziphus mauritiana* Lamk) cultivars on topworking in the semi-arid region of West Bengal. J. App. Hortic., *4*(1): 49-51.

GODI, N.F., V.R. JOSHI, V.S. SUPE (2016): Physical fruit characteristics assessment of selected Ber (*Ziziphus mauritiana* Lamk.) genotypes. Int. J. App. Res., *2*(2): 757-761.

GOLDENBERG, L., Y. YANIV, T. KAPLUNOV, A. DORON-FAIGENBOIM, R. PORAT, N. CARMI (2014): Genetic diversity among mandarins in fruit-quality traits. J. Agric. Food Chem., *62* (21): 4938-4946.

GUNDUZ, K. and O. SARACOGLU (2014): Changes in chemical composition, total phenolic content and antioxidant activities of Jujube (*Ziziphus jujuba* Mill.) fruit at different maturation stages. Acta Scientiarum Polonorum Hortorum Cultus, *13* (2): 187-195.

HORTWITZ, W. (1960): Official methods of analysis of the association of official analytical chemists. Association of Official Analytical Chemists, Washington, DC. pp. 314-320.

HULME, A.C. (1971): The Biochemistry of Fruits and Their Products, Academic Press, London, England. p. 537- 554.

ISHFAQ, M., I.A. HAFIZ, A. HUSSAIN, G.A. CHAUDHARY (1999): Growth, yield and fruit quality of sweet orange varieties under raindfed conditions of Chakwal. Int. J. Agric. Biol., *1* (3):100-102.

JAWANDA, J.S. and J.S. BAL (1978): Ber- highly paying and rich in food value. Indian Horticulture, *23*(3): 19-21.

JAWANDA, J.S. and J.S. BAL (1981): Ber cultivation in Punjab. Punjab Horticultural Journal, *21*(1/2): 17-22.

JIANG, X.W., J.Q. CAO, J.X. ZENG, F.P. HUANG (2006): Jujube cultivars trials and study on their adaptability. South China Fruits, *1*: 51-52.

KALT, W. (2005): Effects of production and processing factors on major fruit and vegetable antioxidants. J. Food Sci., *70*:11-19.

KAMILOGLU, O., S. ERCISLI, M. SENGÜL, C. TOPLU, S. SERCE (2009): Total phenolics and antioxidant activity of jujube (*Zizyphus jujube* Mill.) genotypes selected from Turkey. Afr. J. Biotech., *8*: 303-307

KUMAR, R. (2012): Effect of climate change and climate variable conditions on litchi (*Litchi chinensis* Sonn.) productivity and quality, in: IV International symposium on Lychee, Longan and Other Sapindaceae Fruits. Acta Horticulturae, *1029*: 145-154.

MARSH, K.B., A.C. RICHARDSON, Y. ERNER (2000): Effect of environmental conditions and horticultural practices on citric acid content. Proceeding of the 9th International Citrus Congress, Orlando, FL, International Society of Citriculture. pp. 640-643.

MEENA, S.K., N.K. GUPTA, S. GUPTA, S.K. KHANDELWAL, E.V.D. SASTRY (2003): Effect of sodium chloride on the growth and gas exchange of young Ziziphus seedling rootstocks. J. Hortic. Sci. Biotech., *78* (4): 454-457.

MOHAR, T.A., M.M. ABBAS, M.Z. AWAN, M.A. JAVED, A. FAROOQ (2011): Performance of different sweet orange varieties under Faisalabad conditions. J. Agric. Res., *49*(3): 363-367.

MOULY, P.P., E.M. GAYDOU, R. FAURE, J.M. ESTIENNE (1997): Blood orange juice authentication using cinnamic acid derivatives. Variety differentiations associated with flavanone glycoside content. J. Agric. Food Chem., *45*(2): 373-377.

NAWAZ, M.A., W. AHMED, M. MAQBOOL, B.A. SALEEM, Z. HUSSAIN, M. AZIZ, A. SHAFIQUE (2012): Characteristics of some potential cultivars for diversification of citrus industry of Pakistan. Int. J. Agric. App. Sci., *4*(1): 58-62.

OZGEN, M., F.J. WYZGOSKI, A.Z. TULIO, A. GAZULA, A.R. MILLER, J.C. SCHEERENS, R.N. REESE, S.R. WRIGHT (2008): Antioxidant capacity and phenolic antioxidants of midwestern black raspberries grown for direct markets are influenced by production site. Hort. Sci., *43*(7): 2039–2047.

OZGEN, M, J.C. SCHEERENS, R.N. REESE, R.A. MILLER (2010): Total phenolic, anthocyanin contents and antioxidant capacity of selected elderberry (*Sambucus canadensis* L.) accessions. Pharmacognosy Magazine, *6*(23): 198-208.

QAMER, S, M. EHSAN, S. NADEEM, A.R. SHAKOORI (2007): Free amino acids content of Pakistani unifloral honey produced by Apis mellifera. Pak. J. Zool., *39*(2): 99-102.

RAPISARDA, P., G. CAROLLO, B. FALLICO, F. TOMASELLI, E. MACCARONE (1998): Hydroxycinnamic acids as markers of Italian blood orange juices. J. Agric. Food Chem., *46*(2): 464-470.

RAZI, M.F., R. ANWAR, S.M.A. BASRA, M.M. KHAN, I.A. KHAN (2013): Morphological characterization of leaves and fruit of jujube (*Ziziphus mauritiana* Lamk.) germplasm in Faisalabad, Pakistan. Pak. J. Agric. Sci., *50*: 211-216.

REICH, L. (1991): Uncommon fruits worthy of attention: a gardener's guide. Addison-Wesley Publishing, Massachusetts, USA, pp. 173-183.

RUCK, J. (1963): Chemical Methods for Analysis of Fruit and Vegetable Products. Research State of Summerland, Research Branch, Canada Department of Agriculture, Publication No. 1154.

SARIDAS, M.A., N.E. KAFKAS, M. ZARIFIKHOSROSHAHI, O. BOZHAYDAR, S.P. KARGI (2016): Quality traits of green plums (*Prunus cerasifera* Ehrh.) at different maturity stages. Turk. J. Agric. Forestry, *40*: 655-663.

SAS INSTITUTE (2005): SAS Online Doc., Version 8. SAS Inst., Cary, NC, USA

SHARMA, G.N. and A. GAUR (2013): *Ziziphus mauritiana* Lamk-an overview. Indo American J. Pharmaceutical Res., *3*(6): 4560-4566.

SHELLIE, K.C. and R.L. MANGAN (1994): Postharvest quality of Valencia'Orange after exposure to hot, moist, forced air for fruit fly disinfestation. Hort. Sci., *29* (12): 1524-1527.

VON CARLOWITZ, P.G, P.K.R. NAIR, A. YOUNG, G. TRAXLER, D. BYERLEE, J. BAANANTE, S. CASTILLO (1991): Multipurpose trees and shrubs: sources of seeds and inoculants. ICRAF, Nairobi (Kenia).

WASEEM, K., A. GHAFFOOR, S.U. REHMAN (2002): Effect of fruit orientation on the quality of litchi (*Litchi chinenesis* Sonn) under the agro-climatic conditions of Dera Ismail Khan-Pakistan. Int. J. Agric. Biol., *4*: 503-505.

ZORENC, Z., R. VEBERIC, F. STAMPAR, D. KORON, M. MIKULIC-PETKOVSEK (2016): Changes in berry quality of northern highbush blueberry (*Vaccinium corymbosum* L.) during the harvest season. Turk. J. Agric. Forestry, *40*: 855-867.

ZOZIO, S., A. SERVENT, G. CAZAL, D. MBEGUIE-A-MBEGUIE, S. RAVION, D. PALLET, H. ABEL (2014): Changes in antioxidant activity during the ripening of jujube (*Ziziphus mauritiana* Lamk). Food Chem., *150*: 448-456.

ZVAIGZNE, G., D. KARKLINA, D. SEGLINA, I. KRASNOVA (2009): Antioxidants in various citrus fruit juices. Chemine Technologija, *3*(52): 56-61.

GENETIČKA RAZNOLIKOST KARAKTERISTIKA KULTIVARA *Ziziphus mauritiana*

Wajeeha AMIN[1], Sajjad HUSSAIN[1], Muhammad Akbar ANJUM[1], Shaghef EJAZ[1], Muhammad SAQIB[1], Muhammad Fasih KHALID[1], Sezai ERCISLI[2*], Shakeel AHMAD[3]

[1]Departman za hortikulturu, Fakultet za poljoprivredne nauke i tehnologiju, Bahauddin Zakariya Univerzitet, Multan, Pakistan
[2]Departman za hortikulturu, Poljoprivredni fakultet, Ataturk Univerzitet, Erzurum, Turska
[3]Departman za poljoprivredu, Fakultet za poljoprivredne nauke i tehnologiju, Bahauddin Zakariya Univerzitet, Multan, Pakistan

Izvod

Ovo istraživanje je sprovedeno na pet kultivara *Ziziphus mauritiana* Lamk. Anokhi, Karela, Dill bahar, Ajooba i Dehli white, koji su gajeni na dve lokacije u Pendžabu, Pakistan u toku sezona 2014-2015 i 2015-2016. Cilj je bio utvrđivanje genetičke raznovrsnosti zasnovane na voćnim osobinama ploda (težina, dužina, prečnika), semena (težina, dužine, prečnika), težini pulpe, pH sokova, ukupnih rastvorljivih čvrstih materija (TSS), vitaminu C, šećerima (ukupni, redukujući i neredukujući), antioksidativnom kapacitetu i ukupnim fenolima. Svi kultivari značajno su se razlikovali jedni od drugih po svojim fizičko-hemijskim osobinama. Dehli white kultivar imao je najvišu težinu ploda (22,90 g), prečnika voća (37,58 mm), težinu pulpe (16,83 g) i prečnik semena (10,33 mm) u odnosu na druge sorte. Dill bahar je imao najvišu dužinu ploda (43,75 mm), težinu semena (2,69 g), pH sokova (4,98), sadržaj vitamina C (55,86 mg / 100 mL sok) i ukupan sadržaj fenola (146,98 mg GAE po ml). Anokhi je imao najveću dužinu semena (26,13 mm), neredukujuće šećere (37,81%), ukupne šećere (47,23%) i antioksidativni kapacitet (1016,8 mM troloka na 100 mL). U uslovima životne sredine Bahavalpura i Faisalabada Dehli white i Dill bahar su imale bolje fizičke osobine. Međutim, sorte Ajooba i Anokhi su bile bolje u Bahavalpuru na osnovu biohemijskih svojstava.

Primljeno 22.X.2017.
Odobreno 18. II. 2018.