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Research Article

IMPACT OF CLIMATE ZONES ON EXOTIC DATE PALM GERMPLASM

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Abstract

Date palm (*Phoenix dactylifera* L.) is a remarkable crop in arid/semi-arid zone of the world. South region of Punjab, Pakistan is best suited for date culture, but abrupt change in climate is alarming. A research study was conducted at Horticultural Research Station, Bahawalpur on five years old plants of 15 date palm exotic cultivars viz Sultana, Shishi, Sugai, Nabtul-Saif, Khudri, Khalas, Barhee, Amber, Ajwa, Medjoul, Raziz, Lulu, Nemeishi, Zamli and Dhaki (as Control) during 2019-2021. Three years' data were recorded on temperature, humidity, rainfall, plant height, stem girth, number of fronds, frond length, frond width, number of pinnae per frond, fermented fruit %, yield and economic return per plant (Khalal & Tamar), reduction in yield from Khalal to Tamar. Nabtul-Saif excelled in plant height (4.5m), stem girth (2.5m), number of fronds (39), frond length (2.7m), frond width (81cm) and quantity of pinnae per frond (153). Barhee proved to be the best as Khalal due to its tolerance against rains (24% fermented fruit) and the highest average Khalal yield (75kg), fetching maximum income (7000 PKR) per plant. Ajwa variety led in Tamar yield (37kg) due to lesser reduction in yield (40%) from Khalal to Tamar earning maximum return (6200 PKR) per plant from its Tamar. Medjoul variety showed versatility as it was less affected by Monsoon rains (25% fermented fruit) higher Khalal (70kg) and Tamar yield (36kg) with higher return (6200 PKR) from Tamar. Khudri with 53% and Nemeishi with 48% fermented fruit were badly affected from Monsoon rains. Based on the results, Barhee variety is more suitable for south Punjab region.

Keywords: *Climate change, cultivars, Phoenix dactylifera, production, precipitation*.

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1. Introduction

Date palm (*Phoenix dactylifera* L.) is a resourceful plant that gives not only revenue to private farmers but also income to public sector in the areas known as arid and semi-arid worldwide. Date palm is somewhat tolerant to soil salinity and alkalinity, and its successful cultivation in scorching dry deserts of the world proves proverb that its feet (roots) be in water (abundant underground water enclose the top or irrigation) and head (crown) in fire (excessive heat), the conditions prevail in oases and valleys of Middle East, the original center of date palm. It can grow from 12.7 to 27.5 °C average temperature, withstanding up to 50 °C and sustaining short periods of frost at temperatures as low as –5 °C. The range of ideal temperature for its cultivation is 21 to 27 °C on standard basis from pollination till fruit ripening. Normally, it needs long hot summer days with low intensity rainfalls and less atmospheric humidity at the time of pollination and

ripening till harvesting. Date palms are extensively cultivated in the area located among 15ºN and 35ºN from the west of Morocco to the east of Indian (Zaid and de Wet, 2002).

Global production of dates (9.7 million tonnes) was recorded in 2022. Rounding off the top ten countries, Egypt is at the top with 1.7, followed by Saudi Arabia (1.6), Iran (1.3), Algeria (1.2), Iraq (0.8), Pakistan & Sudan both with 0.5, Oman & United Arab Emirates both with 0.4 and Tunisia (0.3) million tonnes dates respectively (FAO, 2022).

Pakistan is playing pivotal role in date export and production. Pakistan exported 107624 tonnes dried dates worth of 6414 million Pakistani Rupees and produced 83825 tonnes dates over an area of 96514 hectares during 2021-22. Baluchistan province led in production of dates (594962 tonnes) from 53767 hectares, followed by Sindh province with 224030 tonnes from 41026 hectares. Punjab province contributed 43350 tonnes dates over an area of 4750 hectares and Khyber Pakhtunkhwa shared 14924 tonnes in production from a region of 38971 hectares (Fruits, Vegetables & Condiments Statistics of Pakistan, 2022).

Dates supply a reasonable quantity of energy, sugars, fiber, minerals and vitamins. One hundred gram dried dates (Tamar) provide the units of calories/nutrients and their percentage of daily needs. Being nutritious fruit and a source of antioxidants, dates exhibited potential benefits help brain, digestive, cardiac health, protect against disease and ease natural labor (Essa *et al*., 2016; Al-Shwyeh, 2019).

Date palm is a beneficial plant having excellent qualities to work valuable part in assist ecological equilibrium with vegetative life under hard arid climate and in sandy saline soil. Being tall with reasonable canopy, it is capable of absorbing high atmospheric carbon dioxide, as much as the other trees do, with great ability to combat the global warming just like lungs purifying carbon dioxide into oxygen and food stuff imitating Amazon's rainforest (Sharif *et al*., 2010). Date culture providing not only livelihood to oasis people but also shelter from hot windy desert conditions of Biskra Oasis by altering desert oasis impact into adaptable microclimate (Tarai *et al*., 2014).

For date fruit maturity, long dry hot summer with 10-40 °C temperature range is requisite. Middle East region growing date palm is under threat of climate change, hence facing reduction in income from dates because of diseases and drought resulted from changing climate in the decade from 1990 to 2000 (Zaid and Arias Jimenez, 2002). Early flowering in date palm due to changed climate has been observed by growers of Saudi Arabia (Darfaoui and Assiri, 2009). Present and upcoming date palm cultivation may be decreased drastically in Saudi Arabia (Allbed *et al*., 2017) and 129 million hectares' suitable area (68%) of this country will become unsuitable, 13 million hectares' unsuitable area (33%) of Iran become suitable as well as Israel, Jordan and western Syria set off further adaptable for date palm growing by 2050 (Shabani *et al*., 2012; Shabani *et al*., 2014; Shabani *et al*., 2015). Date palm biology, phenology, pollination, fruit maturity, harvesting, production and earning have been influenced negatively under variant climate impact (Shabani *et al*., 2016). Date growing region may have aridity because of less rains or flooding due to high rains altering technique of rain distribution in a specific area as more rains occurred in winter (33%) and spring (37%) during 2001-13 than the previous decade (1990-2000) in which rains occurred 37% in autumn and 39% in winter at Biskra Oasis. Hence, date culture has extended on 0.16 million hectares of Algerian Sahara carrying 15 million date palms as new distribution of rainfall may

affect the fecundation and production of dates (Tarai *et al*., 2014).

Some suitable areas of Pakistan may set off climatically not favorable in net generation for date palm growing due to severe consequences of climate change, resulting in to area decline as date palm is already not growing in its climatically favorable orbit (Farooq *et al*., 2021).Therefore, due to seasonal converting biophysical relation would change irrigation doses, soil qualities and increase the danger of pests and diseases thereby effecting agricultural production in Pakistan (Mustafa, 2011). Sindh province producing 309696 tons dates in years 2017-18 as periodical (Monsoon) rainfall was mainly defective over southern Pakistan area (Sindh & Balochistan) and less normal elsewhere. Whereas, 40% decrease in production was recorded during 2018-19 because during monsoon (Jul-Sep) season of 2019, the seasonal precipitation was near to common in Baluchistan, while it standing beyond normal in Sindh province (Anonymous, 2019). The major reason could be beyond normal rains in Monsoon 2019 because of climate alter which effectively hit date crop in Sindh province. The annual precipitation of Punjab province of Pakistan has increased by 228 mm, summer monsoon precipitation increased by 111.2mm and winter precipitation has increased by 59.6mm during 1901-2007 (Chaudhry *et al*., 2009) which shows alarming condition for date palm growing in Punjab province. Effect of climate change on date palm diverted interest of researcher to search such date cultivars which would be rain-permit at maturing moment. In various date cultivated area globally, precipitation resemble with the ripening event and causes fermented low-standard fruit. Less fruit setting due to rainfall during or after pollination is a general concern, but great concern is the rainfall at fruit ripening. Amount of rain, providing humidity and wind during fruit maturing and maturity determine the future balance from date production (Bashir *et al*., 2015). Rain that occurs just after pollination may act as a washing agent to take out majority of the applied pollen as well as low temperatures accompanied by rain causing negative effect on fruit set. Flower's receptivity may reduce after contact with water affecting fertilization and fruit set. Date growers would have to repeat pollination after 4 to 6 hours preceding pollination. Rains also increase relative humidity in environment that cause cryptogamic diseases leading to inflorescences rotting. Light spring shower with high relative humidity and warm temperature before pollination may cause Khamedj disease (Mauginiella schaettae). It is valuable highlight that the quantity of any particular precipitation is of minimum beneficial than the events under which it occurs. A light fall go along by prolonged interval of cloudy weather and highly relative humidity may affect more risk than heavy rain along by clean weather and dry air (Zaid and de Wet, 2002). Humid season as a result of precipitation or atmospheric humidity may be injurious to date fruit, but damage depends upon ripening stage of fruit. The highly affect occurred by precipitation occurs when either the rain is earliest, or the dates are delay in maturing. In fact, rain does not impact the dates when they are still at the early Khalal moment, but rather has a useful affect by washing out over dust and sand particles from the fruits. Precipitation can therefore occur high inspecting and splitting in the Kimri and late Khalal moments. Continuous rains or abundant atmospheric humidity may ferment the fruit subjecting the fruit to fungi and insect attack. Phenology and geographic spread of date palm is also under impact of newly climate alternate. Date cultivars must adapt changes in farming practices, cropping patters by using new technologies and developing rain-tolerant date cultivars to reduce the affect of climate changing by wise

charge of resources as a crucial scheme to touch the dare. They are mandatory to wilted dates under sunshine because of non-availability of another drying and approaching sections. Like-wise, a huge quantity of date palm farmers propagates plants from suckers have grower and reduced grant to best germplasm for standard production.

Keeping in view climate change. the current study aims to check the impact of climatic factors on economical production of different date palm varieties as well as for promotion of future date palm industry in Pakistan.

2. MATERIALS AND METHODS

Numerous date palm straining with healthier flexibility and high-quality features (better superiority and produce) have been established at Bahawalpur (Pakistan) in the previous for upcoming study and assessment. Spreading of monsoon hails has been altered because of altering worldwide weather which is a danger to date fruits that mature throughout the similar period. Fermented and inferior excellence fruit consequences into a slight produce and very little revenue or entire crop disaster. Present exercise was announced to evaluate the influence of climate alteration particularly monsoon hails and temperature on the manufacture and excellence of bizarre germplasm of Date palm. Present experiment was led throughout 2019, 2020 and 2021 on 5-year old healthy, vigorous, creative, unchanging sized insects & disease free 75 plants from fifteen cultivars of Date palm established at trial farm of Horticultural Research Station, Bahawalpur (Altitude 115m, Longitude 71.65°E, Latitude 29.38°N) space out in square system (plant to plant= 18 feet and row to row = 18 feet) under dominant climate of South Punjab (Pakistan). The experiment was placed out in randomized whole block design with 5 replications of fifteen i.e., 15 cultivars viz Sultana, Shishi, Sugai, Nabtul-Saif, Khudri, Khalas, Barhee, Amber, Ajwa, Medjoul, Raziz, Lulu, Nemeishi, Zamli and Dhaki (as Control). All plants were providing with similar efforts and bundle of field practices like irrigation, fertilizers, pollination, harvesting etc. throughout the investigational period. Facts on numerous vegetative features and output limits i.e., plant height (m**),** stem girth (m), number of fronds, frond length (m), frond width (cm), number of pinnae per frond, fermented fruit (%), Khalal profit per plant (kg), Tamar yield per plant (kg), decrease in produce from Khalal to Tamar (%), coming back from Khalal per plant (‘000’ PKR/Pakistani Rupees), reoccurrence from Tamar per plant (‘000’ PKR) were noted. Plant tallness, stem girth, frond length & width were measured by by means of measuring tape; fermented fruit proportion was assessed by counting amount of fermented fruit and entire fruits per plant by put on following formula:

$$\text{Fermented Fruit } (\%) = \frac{\text{Number of fermented fruits}}{\text{Number of total fruits}} \times 100$$

Khalal yield per plant (kg) has been distinguished by captivating total plant produce during Khalal period from total pickings, yield of Tamar (kg) per plant was restrained by collecting clean healthy fruit from Khalal / Rutab stage and exposing to dehydration or desiccation in fiber glass dessicator for ten days. Decrease in produce from Khalal to Tamar was planned by by means of the formula as under:

$$\text{Reduction in yield from Khalal to Tamar}(\%) = \frac{\text{Khalal yield-Tamar yield}}{\text{Khalal yield}} \times 100$$

Meteorological facts holding of monthly temperature (maximum and minimum ^{o}C), humidity (%), precipitation (mm) for 3 years (2019-2021) in addition to for former 3 years (2016-2018) to associate the climate change were verified from viewpoint of Regional Agricultural Research Institute, Bahawalpur (Bashir *et al*., 2022).

2.1 Data Analysis

Information composed on individually parameter were examined by by means of

software Statistix 8.1 via using One Way ANOVA and variances among treatment means were likened by Tukey HSD all-pairwise comparison test at α=0.05 (Steel *et al*., 1997) for separate year in addition to pooled means from 3 years.

3. Result

3.1 Physical parameters

Maximum average plant height (4.5m) was noted by Nabtul-Saif, followed by Barheei (3.9m) and Amber (3.8m) cultivars. Lulu had minimum plant height (2.5m). Other cultivars ranged from 2.6 m to 3.5 m plant height (Table 1).

Average maximum stem girth (2.5m) was recorded by Nabtul-Saif, followed by Amber (2.4m) and Sugai (2.3m). Lulu showed the minimum stem girth (1.1m). The other cultivars had scale from 1.2 m to 2.2 m stem girth (Table 1).

Maximum number of fronds on average (39) was noted in Nabtul-Saif, followed by Barhee (36) and Sugai (35), while lesser number of fronds (16) was found in Raziz cultivar. Other cultivars ranged from 17 to 34 fronds (Table 1).

Average maximum frond length (2.7m) was noted by Nabtul-Saif, following Barhee (2.6) and Amber (2.5), while the minimum one (1.2m) by Lulu cultivar. All remaining cultivars had scale of frond length from 1.3m to 2 m (Table 2).

Average maximum frond width (81cm) was noted in Nabtul-Saif, followed by Barhee (79cm) and the minimum one (56cm) in Lulu cultivar. Other cultivars ranged from 60cm to 76cm (Table 2).

Average maximum quantity of pinnae per fronds (153) was recorded by plants of Nabtul-Saif, followed by Barhee (148) and Shishi (147) and the minimum number of pinnae per frond (107) was recorded by Lulu cultivar. All other cultivars showed range from 115 to 146 pinnae per frond (Table 2).

3.2 Fermented Fruit Percentage

Barhee cultivar showed the maximum tolerance against monsoon rains as it had the minimum average fermented fruit (24%), followed by Medjoul (25%) in arid region of South Punjab. Highly fermented fruit (53%) was noted by Khudri, following by Nemeishi (48%). Nabtul-Saif, Shishi, Raziz, Amber, Khalas and Ajwa had more than 30% fermented fruit. All these cultivars were very vulnerable to rainfalls. Other remaining cultivars ranged from 27 to 30% fermented fruit (Table 3) indicating moderately acceptable for cultivation keeping in view their market value.

3.4 Khalal Yield

Maximum Khalal yield per plant (75kg) from 3 years' average was obtained by Barhee, followed by Medjoul (70kg). Barhee proved the best to be used as Khalal because of its ability to tolerate rains and the highest yield at Khalal stage. Medjoul ranked 2nd but not good to be used as Khalal. However, Medjoul may provide abundant Khalal fruit for making Tamar from its Khalal. Second group of cultivars which had more than 60kg Khalal yield were Amber (68kg), Sugai (67kg), Dhaki (66kg), Sultana (64kg), Lulu (63kg), Ajwa (62kg), Zamli (61kg) and Khalas (60kg). Although only Sultana, Lulu and Zamli were good to be eaten at Khalal stage, yet other cultivars might be chosen for making Tamar. Minimum Khalal yield (49kg) was found in Khudri because of its higher vulnerability to monsoon precipitation and it had the highest ratio of fermented fruit. All remaining cultivars ranged from 51 to 59kg Khalal dates (Table 3)

3.4 Tamar Yield

Maximum Tamar yield (37kg) was recorded by Ajwa cultivar, followed by Medjoul (36kg) per plant. Bahee and Dhaki both shared Tamar yield (35kg), Amber (34kg), Sultana (33kg), Sugai & Lulu both had 30kg Tamar dates respectively. Medjoul was excellent as Tamar, followed by Amber,

Sugai and Dhaki. Tamar of Barhee, Sultana, Zamli and Khalas was acceptable in quality and flavor. Minimum Tamar dates (24kg) was recorded in Nemeishi, followed by Khudri (25kg) as both were highly vulnerable to monsoon rainfalls and had less Khalal yield to be converted into Tamar.

3.5 Reduction in Yield from Khalal to Tamar

Minimum reduction in yield from Khalal to Tamar (40%) was noted in Ajwa cultivar while maximum reduction (55%) was found in Sugai cultivar from 3 years' average. All other cultivars fluctuated in between 47 and 53% reduction in yield (Table 4). Medjoul, Sultana, Amber, Zamli, Khalas and Dhaki showed good quality of taste and flavor after converting from Khalal to Tamar. Raziz, Lulu and Sugai had acceptable Tamar quality. Other remaining cultivars were not suitable to be disposed of as Tamar in market because of low quality or small fruit size etc. Maximum return from Khalal yield per plant (7000 PKR) was earned from Barhee, followed by Sultana (6100 PKR) on 3 years average basis. Minimum return from Khalal was obtained by Khudri (4200 PKR). The other cultivars ranged from 4500 to 6000 PKR (Table 4).

Biggest take back from Tamar yield per plant (6200 PKR) was achieved by both Ajwa, and Medjoul from 3 years average. Minimum return from Tamar (2700 PKR) was achieved by Nemeishi. All other cultivars ranged from 2800 to 5800 PKR (Table 4).

3.6 Meteorological Data

Higher than 350% raise in precipitation recorded in pollination cycle (February-April) in excessive former 3 years. It impacts pollination, fertilization and fruit setting in Date palm. Intensity of precipitation are raised in May (44%), reduced in June (-47%) and July (-22%) and another time raise in August (144%) than former 3 years, accompany by high than 15% raise in atmospheric humidity in May to July. Raise in precipitation and raise in environmental humidity are impacting date fruit by occurring fermentation of fruit in all form of varieties going to ripe in delay season (August-September). Strength of precipitation in September and October has raised than former 3 years. It shows unlikely for late-season ripening growers e.g. Zamli, Medjoul, Sultana, Sugai and Dhaki and involve more determination to save fruit of late diversities from the effect of altering climate through cover the bunches with polythene bags or by creation chohara from Khalal/Rutab phase of these cultivars. Strength of precipitations throughout October to December has also been enlarged obviously than former 3 years, it advises that implanting of time palm throughout October-November will be fit in upcoming and after implanting some water necessities would also be rewarded by precipitation water. August, 2020 established extreme rain (127 mm), followed by the supreme one (96 mm) in the similar month during 2019 representing frightening condition which might be harmful to late-season date cultivars which persisted harmless from the consequence of hails throughout 3 former previous years. Though numerous of the unusual cultivars are mid-season and persisted continuously defenseless to monsoon precipitations and typically have extra fermented fruit associated to early and late diversities, up till now late mid-season cultivars might be under risk of August showers in coming. Equally years showed that cultivars working to prepared in August (late mid-season) might be defenseless to August precipitations in addition to late-season cultivars would be liable to showers happening in September-October in approaching years as October, 2019 established 86 mm precipitation and September, 2021 established 53 mm precipitation. Though, date cultivars which ripe in September are still harmless from the

injury since September of three years established 23 mm precipitation on usual base. Precipitations at the period of flowering and fertilization happened through February (53mm), March (41mm) and April (40 mm) throughout 2019 and high strength precipitation (103 mm) during March, 2020 is a carefulness for upcoming years to be attentive with deference to flowering and fertilization of date pam (Table 4). Throughout March, 2019 part biased precipitation of the Pakistan continued overhead usual +47%. On local basis precipitation was overhead usual in Balochistan +182%, Sindh +115% and Punjab +21% i.e. in Date rising part excluding Khyber Pakhtunkhwa (CDPC, 2019). Date fruit takings 180-210 days around from fruit usual till maturity. The sensitive phase to precipitation is from full adulthood (Khalal stage) up to ripening (Rutab and Tamer stages). Summer monsoon hails reason continuously a problematic for date palm crop mainly throughout July and August, whether fruit still on the tree or throughout curative procedure on the mats. Other behaviors are to treatment date fruit insincerely in measured champers or dehydrators / desiccators. It is essential in command to dehydrate Rutab fruit to spread Tamar phase where the fruit wetness content a smaller amount than 24%, but in process dehydrators parts are not sufficient to dry extensive quantities of dates throughout the period in Pakistan (Abul-Soad, 2011). As for as date palm concern; all stakeholders, practitioners, policymakers and scientists must be efficient for adaptation, capacity building, changes in policies, implementation of easily operated assessment frameworks to face effect of climate alteration. For example, the Council's Population, Environmental Risk, and Climate Change (PERCC) usages varied facts bases to recruit an interdisciplinary chat on the interconnections of climate alteration and demography through donations from national specialists in meteorology, migration, and agriculture (Sathar and Khan, 2019). Waterfalls during February to April slow down the fertilization procedure and produced fewer fruit situation in altogether unusual date palm cultivars.

4. DISCUSSION

The date palm stem (stipe) is vertical, cylindrical and columnar about the identical girth to the top. Visually observing plant height, suitability and adaptability of a cultivar to a changing climate could be assessed. The terminal bud (phyllophor) when grows vertically, it ensures plant height that may reach up to 20 meters (Zaid and de Wet, 2002). Bashir *et al*., (2022) studied indigenous genepool of date palm to screen rain-tolerant date cultivars under semi-arid climate and found maximum plant height (4.7 m) in cv. Khurma. Changing climate has altered the pattern of annual precipitation in a particular region and areas under date palm may suffer from aridity due to low rainfalls or floods caused by high rainfalls (Tarai *et al*., 2014). Stem girth indicates plant vigor and establishment of a cultivar in the soil of a particular climate. Horizontal or lateral development is assured by an additional fascicular cambium which promptly flade, and which outcome in a stable and balanced trunk width in the palm's whole life. The stem girth does not increase till the frond canopy developed fully. Stem of date palm raises in girth because of movement of apical meristem and not due to intercalary meristem and lateral meristem. Sometimes phyllophor shows abnormality in growth pattern because of deficient mineral nutrition that may cause shrink trunk in prevailing dry climate (Zaid and de Wet, 2002).

A frond is large divided leaf and sometimes is called compound leaf as the whole leaf consists of a petiole and several small pointed leaflets (pinnae). Frond number of a particular variety may be different due to genetics or under variant agro-climatic

conditions. Dried or old fronds do not shed in contrast to other fruit plants, but are pruned according to need of the palm. A full-grown date palm may produce from 100 to 125 fronds with yearly increase from 10 to 26 new fronds. Maintaining the ratio as 8 fronds for one fruit bunch will decide the number of bunches to be retained on that palm (Zaid and de Wet, 2002). A frond may extend in length from 3 to 6 m (average 4m) with an age from 3 to 7 years relaying upon grower, palm age and a particular environment (Zaid and de Wet, 2002). Length of frond directly indicates the development and yield of plant in the region facing climate alter. A lengthy frond may hold more leaflets (pinnae) to produce more food for fruit bunches. Precipitation in climate is dangerous during fruit ripening, but could be boosting to frond growth according to variety, soil and climate (Bashir *et al*., 2022). Frond structure of a variety is environment dependent and under good cultural events a frond can help the yield of 1 to 1.5 kg of dates (Zaid and de Wet, 2002). Adult fronds are pinnate and arise from buds grown by the apical growing point ascending spirally. Frond width consists of collective length of 2 parallel pinnae across the midrib. Pinnae length may range from 15 to over 100 cm (Zaid and de Wet, 2002). Frond width is also indicator which supports the fruit production by providing more leaf area for photosynthetic activity to provide food ingredients to developing fruit. Wet climate at the time of fruit ripening is deleterious but the same time is beneficial to enhance frond width as was reported by Bashir *et al*., (2022) regarding frond length. Usually pinnae range from 120 to 240 per frond and their arrangement varies as per variety in groups of 1, 2, 3, 4, or 5 pinnae (Zaid and de Wet, 2002). A lengthy frond may keep more number of pinnae as compared to a short frond, hence support in manufacturing of nutrients for fruit development.

Highly fermented fruit (53%) was noted by Khudri, following by Nemeishi (48%). Nabtul-Saif, Shishi, Raziz, Amber, Khalas and Ajwa had more than 30% fermented fruit. All these cultivars were very vulnerable to rainfalls. Other remaining cultivars ranged from 27 to 30% fermented fruit (Table 3) indicating moderately acceptable for cultivation keeping in view their market value. Similar findings were reported by Bashir *et al*., (2022) who noted minimum fermented fruit (21%) in Bagum jangi, followed by Zirin (22%) and Haleeni (23%) from indigenous date germplasm while studying effect of semi-arid climate region on date palm. They found Khudrawi the most vulnerable cultivar to rains with 48% fermented fruit, followed by Kupra with 43% fermented fruit just like Khudri and Nemeishi from exotic date germplasm. Date palm culture will be well advanced in regions where winter rainfall is not injurious to date fruits, but benefiting the soils through leaching the deposited surface salts and checking rising motion of salts from underneath coating. Major date-growing regions remain rainless till November, whereby harvesting starts from mid-August to end-October. Rains at flowering and fruit harvesting time may reason harm to the fruit (Zaid and de Wet, 2002). The chance of plant injury by rains in Monsoon in any period is high beneficial than the amount of any particular precipitation in the conditions under which it occurs. A lighten water falling with lengthy cloudy weather and huge

Table 1: Plant Height, Stem Girth and Number of Fronds affected by Climate Regime in Exotic Date Cultivars

Cultivars	Plant Height (m)				Stem Girth (m)				No. of Fronds			
	2019	2020	2021	*Mean	2019	2020	2021	*Mean	2019	2020	2021	*Mean
V_1= Sultana	2.7bc	3.5bd	4.2bd	3.5cd	1.7a*	2.2ab	2.8ac	2.2ac	26ad	32a	43ab	34bd
V_2= Shishi	2.5bc	3.4bd	4.0cd	3.3d	1.6ab	2.1ac	2.7ad	2.1bd	22cd	29ab	40ac	30de
V_3= Sugai	2.6bc	3.6bc	4.2bd	3.4d	1.8a*	2.3ab	2.8ac	2.3ac	28ab	34a*	43ab	35ac
V_4= Nabtul-Saif	3.2a*	4.8a*	5.5a*	4.5a*	1.9a**	2.5a*	3.2a*	2.5a*	30a*	38a**	48a	39a*
V_5= Khudri	2.6bc	3.5b-d	4.0cd	3.4d	1.5ac	2.0ad	2.6ad	2.0ce	24bd	32a*	39ad	32ce
V_6= Khalas	2.4cd	3.4b-d	4.2bd	3.3d	1.4ad	1.9ae	2.4be	1.9de	23bd	31a*	40ac	31ce
V_7= Barhee	2.9ab	3.9b	4.8ab	3.9b	1.3ae	1.8bf	2.3bf	1.8df	27ac	37a**	45ab	36ab
V_8= Amber	2.8ac	3.8b	4.7bc	3.8bc	1.8a	2.4a*	3.0ab	2.4ab	26ad	32a*	41ac	33be
V_9= Ajwa	2.5bc	3.3be	4.2bd	3.3d	1.3ae	1.9ae	2.4be	1.9de	21d	29ab	38be	29e
V_{10}= Medjoul	1.7ef	2.5ef	3.6d	2.6ef	0.9cf	1.5dh	2.1cf	1.5gi	10e	17c	29ef	19fg
V_{11}= Raziz	1.8ef	2.7d-f	3.8d	2.8ef	0.7ef	1.1gh	1.7ef	1.2ij	8e	16c	25f	16g
V_{12}= Lulu	1.5f	2.4f	3.5d	2.5f	0.6f	1.0h	1.6f	1.1j	11e	18c	30d-f	20fg
V_{13}= Nemeishi	2.0de	2.9cf	3.8d	2.9e	0.9cf	1.4eh	2.0df	1.4gh	9e	16c	27f	17fg
V_{14}= Zamli	1.9ef	2.7df	3.7d	2.8ef	0.8df	1.3fh	1.8ef	1.3hj	9e	18c	28f	18fg
V_{15}=Dhaki	2.0de	2.8cf	3.8d	2.9e	1.0bf	1.6cg	2.2cf	1.6fh	10e	20bc	32cf	21f

Significant values are represented by * and highly significant data in the form of **

Table 2: Frond Length, Frond Width and Number of Pinnae/Frond affected by Climate Regime in Exotic Date Cultivars

Cultivars	Frond Length (m)				Frond Width (cm)				No. of Pinnae/Frond			
	2019	2020	2021	*Mean	2019	2020	2021	*Mean	2019	2020	2021	*Mean
V_1= Sultana	1.1bd	1.7cd	2.4cd	1.7bd	62ad	71ae	81ae	71be	130ab	138b	164ab	144bc
V_2= Shishi	1.0ce	1.8cd	2.5cd	1.8bc	60ad	73ad	84ad	72bd	132ab	142ab	166ab	147ac

V_3= Sugai	1.0ce	1.7cd	2.3cd	1.6ce	59ae	72ae	82ae	71be	126ac	140b	162b	143bc
V_4= Nabtul-Saif	1.6a*	2.9a	3.7a*	2.7a**	70a**	80a*	92a*	81a	136a*	152a*	170a*	153a*
V_5= Khudri	1.1bd	1.8cd	2.4cd	1.7bd	61ad	70ae	81ae	70cf	128ac	142ab	164ab	145bc
V_6= Khalas	1.4ac	2.1bc	2.7cd	2.0b	64ac	76ac	85ad	75ac	135a	144ab	163b	147ac
V_7= Barhee	1.6a*	2.8a*	3.6a*	2.6a*	69a*	78ab	90ab	79a	124ac	145ab	167ab	149ab
V_8= Amber	1.5ab	2.6ab	3.5ab	2.5a*	66ab	75ad	88ac	76ab	120bd	142ab	164ab	142c
V_9= Ajwa	1.1bd	1.8cd	2.8bc	1.9bc	59ae	68bf	78ce	68df	116cd	126c	146c	129d
V_{10}= Medjoul	0.8de	1.2de	2.4cd	1.5ce	52ce	66cg	79be	66eg	100ef	122cd	134de	119ef
V_{11}= Raziz	0.7de	1.1de	2.2cd	1.3de	50de	59fg	72ef	60gh	94f	112de	132e	113fg
V_{12}= Lulu	0.6e	1.0e	2.0d	1.2de	46e	57g	66f	56h	92f	108e	120f	107g
V_{13}= Nemeishi	0.9de	1.6ce	2.2cd	1.6ce	54be	65dg	76df	65fg	98ef	114de	136de	116f
V_{14}= Zamli	0.8de	1.4de	2.3cd	1.5ce	50de	62eg	74df	62gh	96f	112de	138ce	115f
V_{15}=Dhaki	1.0cde	1.7cd	2.3cd	1.7bd	58ae	71ae	79be	70cf	110de	122cd	142cd	125de

Significant values are represented by * and highly significant data in the form of **

Table 3: Fermented Fruit Percentage, Khalal and Tamar Yield per plant affected by Climate Regime in Exotic Date Cultivars

Cultivars	**Fermented Fruit (%)**				**Khalal Yield/plant (kg)**				**Tamar Yield/plant(kg)**			
	2019	**2020**	**2021**	***Mean**	**2019**	**2020**	**2021**	***Mean**	**2019**	**2020**	**2021**	***Mean**
V_1=Sultana	26cf	29ef	28fh	28fi	54be	65ad	72ad	64cf	29ac	33ae	36ae	33ad
V_2= Shishi	33bd	40c	37ce	37cd	48dg	56cg	62cf	55gh	26ad	29ae	33be	29dg
V_3= Sugai	28bf	30df	29eh	29fg	60ac	67ac	74ac	67bd	28ad	30ae	32be	30cf
V_4= Nabtul-Saif	35b	42bc	39bc	39b	44eg	51fg	62cf	52hi	21cd	25de	31ce	26fh
V_5= Khudri	50a**	57a*	53a*	53a**	41g	50g	56f	49i	20d	26ce	30de	25gh
V_6= Khalas	29bf	36ce	32cg	33ce	50cg	59bg	71ae	60fg	23bd	28ae	33be	28eh
V_7= Barhee	23f	25f	23h	23i	66a*	75a*	83a*	75a*	31ab	35ac	39ac	35ab

V_8= Amber	32be	37ce	33cg	34ce	61ac	68ab	75ab	68bc	30ab	34ad	38ad	34ab
V_9= Ajwa	30bf	34cf	32cg	32de	54be	62bf	70be	62cf	32a*	37a*	42a*	37a*
V_{10}= Medjoul	25df	28ef	23h	25hi	62ab	70ab	78ab	70ab	33a*	36ab	40ab	36ab
V_{11}= Raziz	34bc	39cd	35cg	36cd	47dg	54dg	60df	54hi	25ad	27be	30de	27fh
V_{12}= Lulu	26cf	34cf	30eh	30eg	53bf	60bg	69be	63cf	26ad	29ae	34ae	30cf
V_{13}= Nemeishi	45a*	51ab	48ab	48a*	42fg	53eg	59ef	51hi	21cd	24e	28e	24h
V_{14}= Zamli	24ef	29ef	27gh	27gi	55ae	61bg	68bf	61eg	29ac	32ae	35ae	32be
V_{15}=Dhaki	28b-f	30df	28fh	29fg	58ad	64ae	76ab	66be	31ab	34ad	39ac	35ab

Significant values are represented by * and highly significant data in the form of **

Table 4: Percent Reduction in Yield from Khalal to Tamar, Return from Khalal and Tamar per plant affected by Climate Regime in Exotic Date Cultivars

Cultivars	**Reduction in Yield from Khalal to Tamar (%)**				**Return from Khalal/plant ('000' PKR)**				**Return from Tamar /plant ('000' PKR)**			
	2019	**2020**	**2021**	***Mean**	**2019**	**2020**	**2021**	***Mean**	**2019**	**2020**	**2021**	***Mean**
V_1=Sultana	46ab	49ab	50ab	48cd	4.9a-c	6.2ab	7.2ab	6.1b	2.9c	3.6ce	4.3de	3.6ce
V_2= Shishi	46ab	48b	47bc	47d	3.8c-f	4.8df	5.6ce	4.7ef	2.6cd	3.2cf	4.0df	3.3eg
V_3= Sugai	53a**	55a**	57a**	55a**	4.8a-c	5.7b-d	6.7b	5.7bc	4.2b	5.1b	5.8b	5.0b
V_4= Nabtul-Saif	52a*	51ab	50ab	51a-d	3.5ef	4.3f	5.6ce	4.5fg	2.1d	2.8ef	3.7ef	2.9gh
V_5= Khudri	51a*	48b	46bc	48cd	3.3f	4.2f	5.0e	4.2g	2.0d	2.9ef	3.6ef	2.8gh
V_6= Khalas	54a**	52ab	53ab	52ac	4.0bf	5.0c-f	6.4bc	5.1de	2.5cd	3.4cf	4.3de	3.4df
V_7= Barhee	53a**	52ab	53ab	53ab	5.9a**	6.9a**	8.1a**	7.0a**	3.1c	3.9c	5.1bc	4.0c

V_8= Amber	51a*	50ab	49ab	50bd	4.9ac	5.8bc	6.8b	5.8b	4.8ab	5.8ab	6.9a*	5.8a*
V_9= Ajwa	41b	40c	40c	40e	4.3b-f	5.3be	6.3bd	5.3cd	4.8ab	6.3a**	7.6a**	6.2a**
V_{10}= Medjoul	47ab	48b	49ab	48cd	5.0ab	6.0ab	7.0b	6.0b	5.3a**	6.1a	7.2a**	6.2a**
V_{11}= Raziz	47ab	50ab	50ab	49bd	3.8c-f	4.6ef	5.4de	4.6fg	2.5cd	3.0df	3.6ef	3.0fh
V_{12}= Lulu	51a*	52ab	51ab	51ad	4.5b-e	5.4be	6.6b	5.5bd	2.6cd	3.2cf	3.7ef	3.2eh
V_{13}= Nemeishi	50ab	55a**	52ab	52ac	3.6d-f	4.8df	5.6ce	4.7ef	2.1d	2.6f	3.4f	2.7h
V_{14}= Zamli	47ab	48b	48bc	48cd	4.7b-d	5.5be	6.5bc	5.6bd	3.2c	3.8cd	4.6cd	3.9cd
V_{15}=Dhaki	46ab	47b	49ab	47d	4.6b-e	5.4be	6.8b	5.6bd	4.7ab	5.8ab	7.0a	5.8a

Significant values are represented by * and highly significant data in the form of **

Table 5: Meteorological data during 2019-2021 with 3 years averages and % increase / decrease over previous 3 years.

Year	Temp. (ºC)		Humidity %	Rainfall (mm)	Temp. (ºC)		Humidity %	Rainfall (mm)	Temp. (ºC)		Humidity (%)	Rainfall (mm)	Temp. (ºC)		Humidity (%)	Rainfall (mm)
	Min.	Max.			Min.	Max.			Min.	Max.			Min.	Max.		
2016	07	18	69	00	10	25	68	03	14	28	76	32	21	35	65	04
2017	07	18	89	08	11	28	73	05	18	34	74	00	25	37	71	00
2018	08	21	82	00	10	29	74	03	20	35	74	01	22	39	72	07
Avg.	**07**	**19**	**80**	**03**	**10**	**27**	**72**	**04**	**17**	**32**	**75**	**11**	**23**	**37**	**69**	**04**
2019	03	18	83	09	03	16	82	53	11	21	83	41	17	31	87	40
2020	04	14	82	19	08	20	75	00	09	23	82	103	17	33	78	13
2021	05	17	88	00	12	30	80	00	19	36	79	18	22	40	71	02
Avg.	**04**	**16**	**84**	**09**	**08**	**22**	**79**	**18**	**13**	**27**	**81**	**54**	**19**	**35**	**79**	**18**
%(+/-)	-43	-19	+5	+200	-20	-19	+10	+350	-23	-16	+8	+391	-21	-5	+15	+350
	May				**June**				**July**				**August**			
2016	27	42	60	02	27	43	60	02	26	41	68	11	28	38	76	07
2017	27	45	76	15	29	42	74	102	29	43	69	39	30	39	81	11
2018	25	42	70	10	27	44	74	17	28	42	79	128	29	41	83	84
Avg.	**26**	**43**	**69**	**09**	**28**	**43**	**69**	**40**	**28**	**42**	**72**	**59**	**29**	**39**	**80**	**34**
2019	28	40	78	22	27	45	81	26	25	45	88	00	25	40	89	96
2020	23	44	76	14	27	48	75	0	22	42	76	83	25	42	79	127
2021	24	43	85	04	25	48	82	37	26	48	85	56	25	39	73	27
Avg.	**25**	**42**	**80**	**13**	**26**	**47**	**79**	**21**	**24**	**45**	**83**	**46**	**25**	**40**	**80**	**83**
%(+/-)	-4	-2	+16	+44	-7	+9	+15	-47	-14	+7	+15	-22	-14	+3	00	+144
	September				**October**				**November**				**December**			
2016	29	39	63	0	23	37	63	00	17	33	63	00	11	27	73	00
2017	28	40	82	0	21	38	72	00	21	30	75	50	10	26	78	15
2018	28	40	84	02	26	40	74	00	17	35	83	0	07	25	84	00
Avg.	**28**	**40**	**76**	**01**	**24**	**38**	**70**	**00**	**18**	**33**	**74**	**17**	**09**	**26**	**78**	**05**
2019	26	38	86	16	24	37	84	86	19	31	79	220	05	15	73	23
2020	37	25	78	00	26	35	81	00	18	32	85	00	06	14	73	00
2021	27	40	80	53	26	38	74	00	18	30	76	00	08	16	74	00
Avg.	**30**	**34**	**81**	**23**	**25**	**37**	**80**	**29**	**19**	**31**	**80**	**73**	**06**	**15**	**73**	**08**
%(+/-)	+7	-15	+7	+2200	+4	-3	+14	+2900	+5	-6	+8	+329	-33	-42	-6	+60

Source: Regional Agricultural Research Institute, Bahawalpur

humidity may reason high harm than huge precipitation following clean weather and dry air (Zaid and de Wet, 2002). Previously, Bashir *et al*., (2022) considered good date cultivars which ranged Khalal yield from 71 to 85kg from 12-years old plants of indigenous cultivars under semi-arid climate region. In fact, dates are not destroyed by rains at early Khalal stage rather fruit is washed away from dust and sand particles. However, rain might cause fruit cracking at Kimri and late Khalal stages (Zaid and de Wet, 2002). Halawi variety is frequently consumed at Khalal part fetching reasonable income to the farmers of South Punjab, but due to prevailing humidity at its fruit maturation and ripening, its plantation or the plantation of other date varieties is restricted because of prerequisite dry nature eco-system for its growth controlled by various factors (Ata *et al*., 2012). Therefore, Barhee being good at Khalal stage and tolerant to monsoon rains, could be an appropriate replace for Halawi variety in future date plantation. In Pakistan, average fruit yield per date palm is reported to be about 90 kg of which more than half was destroyed by rain, wind and birds. That is why harvested yields were substantially smaller (Fatima *et al*., 2016). The extension of date palm culture to the southern part of the Sahara Desert (Sahel) is exceptional due to heavy rain in July-September and dry period in October-December (Tarai *et al*., 2014).

Barhee proved the best to be used as Khalal because of its ability to tolerate rains and the highest yield at Khalal stage. Medjoul ranked 2nd but not good to be used as Khalal. However, Medjoul may provide abundant Khalal fruit for making Tamar from its Khalal. Second group of cultivars which had more than 60kg Khalal yield were Amber (68kg), Sugai (67kg), Dhaki (66kg), Sultana (64kg), Lulu (63kg), Ajwa (62kg), Zamli (61kg) and Khalas (60kg). The fruit of Dhaki cannot be eaten at Khalal stage due to the high percentage of tannins like Aseel variety. Hence, its Tamar stages are appropriate for use such as Aseel variety (Markhand *et al*., 2010). Medjoul was excellent as Tamar, followed by Amber, Sugai and Dhaki. Tamar of Barhee, Sultana, Zamli and Khalas was acceptable in quality and flavor. Minimum Tamar dates (24kg) was recorded in Nemeishi, followed by Khudri (25kg) as both were highly vulnerable to monsoon rainfalls and had less Khalal yield to be converted into Tamar. Bashir *et al*., (2022) found that Aseel, Zahidi, Kupra and Dhaki cultivars from indigenous germplasm are highy beneficial for creating Tamar under semi-arid climate region. Similarly, major of Pakistani dates fell in the semi-dry (Tamar) category and almost of them but not all are responsive to monsoon precipitation which synchronize with ripening / harvest period (Markhand *et al*., 2010). Rain may cause damage either rain is early or occurs late at ripening. Rutab and Tamar stages are usually hit by rain and prevailing humidity resulting into fruit rot and drop. Rain or cool weather close to cutting may also late fruit ripening. The shelf-life of dates can be increased by drying culture-wise (sun-drying) or laying in low-temperature reserve (Naqvi *et al*., 2015). Khalas and Dhaki showed good quality of taste and flavor after converting from Khalal to Tamar. Raziz, Lulu and Sugai had acceptable Tamar quality. Other remaining cultivars were not suitable to be disposed of as Tamar in market because of low quality or small fruit size etc. However, to get away danger of minimum earning, the substitute method is to turn ripe date fruit into boiled fruit (Chohara) for satisfactory earning from varieties generating standard Chohara fruit like Aseel, Dhaki and Haleeni etc. (Bashir *et al*., 2022). The rate of dried dates is the highest in Sukker-Sindh (Pakistan) Market for dried (boiled) dates locally called ‘Chohara’ (Abul-Soad, 2011). However, numerous cultivers of Sindh province cut

fruit of Aseel cultivar at Khalal stage and boil fruit to make "Chuhara". Otherwise, full crop may destruct and outcome into productive lack in case of monsoon precipitation (Makhand *et al*., 2010). Quantity and quality of Tamar depend upon stage of harvesting fruit, its maturity, ripening, method of dehydration & dessication, prevailing humidity, atmospheric & indoor temperature and wind during fruit dehydration; all these factors may decide the future income from date crop. The date growers are forced to dry dates under sunlight because of non-availability of other dry and processed units. Similarly, huge quantity of date palm farmers regenerate plants from suckers having growers and less access to best germplasm for standard yield.

Maximum return from Khalal yield per plant (7000 PKR) was earned from Barhee, Excellence of Barhee over other cultivars could be attributed to its tolerance against rains maintaining the high level of quality at Khalal stage and may be the best future candidate for replacement of Halawi variety in southern Punjab. Previously, Bashir *et al*., (2022) reported maximum average return per plant (3033 PKR) by Khalal dates of Khurma, followed by Halawi (2900 PKR) cultivars from indigenous date germplasm evaluated in Southern Punjab climate regime. The cultivars giving return more than 5000 PKR per plant could be considered suitable for earning from Khalal and those cultivars giving return less than 5000 PKR should be avoided for earning from Khalal stage. Rates of first period dates are each time costly than the mid-season dates. In United Arab Emirates, different just as the cultivar also (Abul-Soad, 2011). The socio-economic situation and food security position in date palm cultivation region in Pakistan are badly record. Earning in agricultural Pakistan can be increased by the on-farm misuse of extra smart post-harvest and selling of dates. While, restriction in date growing region with lower standard of date palm growers, poor farm controlling, insufficiency of operating facilities, unreliability in rates at the event of sell and reserve of qualified qualified labor (Fatima *et al*., 2016). Labor for taking and cutting of dates is earned from sector of produce. Cutting of date at Khalal stage is a earliest stage of picking and much beneficial to busied labor in means of return if a cultivar is quick maturing and good producer like Barhee and Halawi producing high return not only to the farmers but also to the busied labor under-going climate. The cultivars earning return from Tamar more than 5000 PKR per plant must be prepared for Tamar making and abstained from those cultivars earning return less than 5000 PKR from Tamar for sale in the market. The excellence of Ajwa over other cultivars could be attributed to its lowest reduction in yield while making Tamar from its Khalal stage keeping the best quality and flavor at Tamar stage as well its attractive position to the Muslims because of sayings of Holy Prophet Muhammad (peace be upon him) about Ajwa. Previously, Bashir *et al*., (2022) mentioned the highest average take back per plant from Tamar dates of Aseel (3800 PKR), followed by Zahidi (3683 PKR) and Dhaki (3683 PKR) from indigenous date cultivars adapted to South Punjab agro-climate.

The entire yearly earning from date palm in Middle Eastern countries has reduced from 1990 to 2000 because of plant diseases and water need outcome from climate alter (Zaid and Arias Jimenez, 2002). In Pakistani Marketplace (Sukkeri, Sindh) rates of Aseel start from low rates (in October) to the high (in December) for restore dates (Abul-Soad, 2011). Fatima *et al*., (2016) noted that major date cultivars tackled with monsoon precipitation in the fruit ripening period (June–October) which could destroy fruits within 2–3 days by reason cracking in the epicarp. Growers getting best take back from Tamar like Ajwa, Medjoul, Amber and Sugai

from exotic elite germplasm would compensate income difference set by Aseel, Zahidi and Dhaki from indigenous date germplasm and would be the good option for next dates industries under prevailing climate of south Punjab (Pakistan).

Conclusion

Weather of southern Punjab is fit for date making but altering climate may hamper the finest class manufacture. Present learning exposed that monsoon showers, humidity and temperature may disturb the manufacture and superiority of bizarre germplasm of Date palm. Khudri and Nemeishi cultivars percentage of fermented fruit were seriously affected by monsoon rains. Nabtul Saif cultivar remained strong in vegetative growth. Barhee led in Khalal yield with maximum return from Khalal, tolerated rains well and might be the finest other diversity for Halawi in south Punjab at Khalal. Ajwa was the best for Tamar making and fetching the highest return from Tamar. Medjoul showed versatile adaptability to climate and fetched good economic return from Tamar. Zamli, Lulu and Sultana also tolerated rains but ripe in late season may replace Dhaki. Amber and Khalas displayed satisfactory features to be apply as 'Tamar' after curing. While among all varieties, Barhee variety was more better for south Punjab region.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

5. References

Abul-Soad, A.A. 2011. Date Palm in Pakistan, Current Status and Prospective. USAID Firms project. DPRI, SALU, Khairpur, Sindh, Pakistan., pp. 1-86.

Allbed, A., L. Kumar and F. Shabani. 2017. Climate change impacts on date palm in Saudi Arabia. J. Agric. Sci., 155: 1203-1208.

Al-Shwyeh, HA. 2019. Date palm (Phoenix dactylifera L.) fruit as potential antioxidant and antimicrobial agents. J.Pharm.Bioallied. Sci. 11(1):1-11.

Anonymous. 2018(b). Monsoon 2018 rainfall update, CDPC Technical Report No. 2/2018 (October), CDPC / Pakistan Meteorological Department.

Anonymous. 2019. Monsoon 2019 rainfall, CDPC Technical Report No. 2/2019 (October), CDPC / Pakistan Meteorological Department.

Ata, S., B. Shahbaz, M. Ahmad and I.A. Khan. 2012. Factors hampering date palm production in the Punjab: a case study of D.G. Khan district. Pak. J. Agri. Sci., 49:217-220.

Bashir, M.A., M. Ikhlaq, A. Noreen, K. Shabir, M.K. Raza and A. Bakhsh. 2022. Effect of semi-arid climate region on quality and production of date palm germplasm. Journal of Pure and Applied Agriculture, 7(4): 46-57.

Chaudhry, Q. Z., A.Mahmood, G. Rasul and M. Afzaal. 2009: Climatic Change Indicators of Pakistan. Technical Report No. PMD-22/2009, Pakistan Meteorological Department, Islamabad. 1-44.

Climate Data Processing Center (CDPC). 2019. Winter Rainfall Update – 2019. Pakistan Meteorological Department. Availabale Online: http://www.pmd.gov.pk/cdpc/winter 2019_rainfall_update.htm.

Darfaoui, E. and A. Assiri. 2009. Response to climate change in the Kingdom of Saudi Arabia. Internal working paper FAO RNE, Cairo, Egypt.

Essa, M.M., M. Akbar and M.A.S. Khan. 2016. Beneficial effects of date palm fruits on neurodegenerative diseases. Neural Regeneration Research, 11(7):1071-1072.

Farooq, S., M. M. Maqbool, M. A. Bashir, M. Ihsan Ullah, R. Shah, H.M. Ali, D.A. Al Farraj, M.S. Elshikh, A.A. Hatamleh, S. Bashir, Y.F. Wang. 2021. Production suitability of date palm under changing climate in a semi-arid region predicted by CLIMEX model. Journal of King Saud University – Science, 33: 1-8

Fatima, G., I. A. Khan and A. Buerkert. 2016. Socio-economic characterisation of date palm (*Phoenix dactylifera* L.) growers and date value chains in Pakistan. Springer plus, 5(1):1222.

Food & Agriculture Organization of United Nations. 2022. Viale delle Terme di Caracalla 00153 Rome, Italy.

Fruits, Vegetables & Condiments Statistics of Pakistan. 2022. Ministry of National Food Security and Research, Economic Wing, Govt. of Pakistan, Islamabad.

Hasan, S., K. Baksh, Z. Ahmad, A. Maqbool and W. Ahmed. 2006. Economics of Growing Date palm in Punjab, Pakistan. International Journal of Agriculture and Biology, 8: 1-5.

Markhand, G.S., A. Abul-soad, A.A. Mirbahar and N.A. Kanhar. 2010. Fruit characterization of Pakistani dates. Pak. J. Bot., 42(6): 3715-3722.

Mustafa, Z. 2011. Climate change and its impact with special focus in Pakistan. In: Anver, R. K. (ed) Proceedings of Symposium on "Changing Environmental Pattern and its impact with Special Focus on Pakistan". Pakistan Engineering Congress, Lahore. 290: 100-117.

Naqvi, S. A., I. A. Khan, J. C. Pintaud, M. J. Jaskani and A. Ali. 2015. Morphological characterization of Pakistani Date palm (*Phoenix dactylifera* L.) genotypes. Pak. J. Agri. Sci., 52(3):645-650.

National Nutrient Database. 2019. Dates Nutrition facts. United States Department of Agriculture. Available online: www.nutrition-and-you.com

Sathar Z.A. and K. Khan (eds). 2019. Climate, Population, and Vulnerability in Pakistan: Exploring Evidence of Linkages for Adaptation. Islamabad: Population Council

Shabani, F., L. Kumar and S. Taylor. 2012. Climate change impacts on the future distribution of Date palms: A modeling exercise using CLIMEX. PLoS ONE 7(10): e48021.

Shabani, F., L. Kumar and S. Taylor. 2014a. Suitable regions for date palm cultivation in Iran are predicted to increase substantially under future climate change scenarios. J. Agric. Sci., 152: 543-557.

Shabani, F., L. Kumar and S. Taylor. 2014b. Projecting date palm distribution in Iran under climate change using topography, physicochemical soil properties, soil taxonomy, land use and climate data. Theoretical and Applied Climatology, 152: 543–557.

Shabani, F., L. Kumar and S. Taylor. 2015. Distribution of date palms in the Middle East based on future climate scenarios. Experimental Agriculture, 51(2): 244-263.

Shabani, F., O. Cacho and L. Kumar. 2016. Effects of climate change on economic feasibility of future date palm production: An integrated assessment in Iran. Human and

Ecological Risk Assessment International Journal.

Sharif, A. O., M. Sanduk and H. M. Taleb. 2010. The date palm and its role in reducing soil salinity and global warming. In: Zaid, A. and G.A. Alhadrami (Ed.), Proc. 4th Int. Date Palm Conference, Acta. Hort. 882: 59-64.

Tarai, N., A. Mihi and M. Belhamra. 2014. The effects of climate change on the date palm productivity at Biskra Oasis, South Algeria. Abstract for 3rd International Conference on Earth Science and Climate Change, July 28-30, 2014, Toronto, Canada.

Zaid, A. and E. J. Arias Jimenez. 2002. Date palm cultivation, FAO plant production and protection paper 156.

Zaid, A. and P. F. de Wet. 2002. Climatic requirements of Date palm. In: Zaid, A. (ed). Date Palm Cultivation. FAO Plant Production and Protection Paper 156 Rev. 1: 95-119.