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Effect of semi-arid climate region on quality and production of date palm germplasm

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Abstract

Twenty Date cultivars viz Hallawi, Makran, Dhaidi, Shakri, Gajjar, Sanduri, Sufaida, Khudrawi, Shamran, Zirin, Zahidi, Aseel, Kupra, Fasli, Pathri, Halwain, Khurma, Dhaki, Bagum jangi and Haleeni were evaluated for the effect of semi-arid climate region on plant height, frond length, fermented fruit percentage, yield per plant from Khalal, Tamar & Chohara, return (PKR) per plant from Khalal, Tamar & Chohara as well as meteorological data on temperature, humidity and rainfalls were recorded during 2017-19 at Horticultural Research Station, Bahawalpur. The treatments (cultivars) were replicated in thrice according to randomized complete block design. Khurma cultivar on 3 years average base obtained maximum plant height (4.7 m), frond length (4.2 m), return from Khalal (Rs. 3033/plant). Zahihi achieved maximum yield of Khalal (120 kg/plant), Tamar (102 kg/plant), and Aseel gave maximum Chohara (87 kg/plant), highest return from Tamar (Rs. 3800/plant) & Chohara produce (Rs. 4053/plant). Minimum fermented fruit (21%) was noted in Bagum jangi and maximum fermented fruit (48%) was found in Khudrawi. More than 100% increase in rainfalls during pollination months (February-April), more than 60% increase in rainfalls & more than 10% increase in atmospheric humidity during fruit ripening months (May-August) over previous 3 years was recorded. Total rains during July-August 2017 & 2018 increased 660% & 1000% from preceding year 2016 respectively, alarming risk to date palm industry in region due to changing climate. Current study revealed that Khurma, Halawi, Dhaidi & Makran are best suited for Khalal; Aseel, Zahidi, Kupra & Dhaki cultivars are very good for Tamar; and Aseel, Dhaki Haleeni are most suitable for Chohara compensating loss due to rains, fetching high income from Chohara produce under semi-arid region of South Punjab. Parameters were positively correlated with each other except fermented fruit %. All parameters were negatively correlated with fermented fruit % except frond length.

Keywords: Climate change, Cultivars, *Phoenix dactylifera*, Productivity, Rainfalls

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Introduction

Phoenix dactylifera L. is one of most valuable plants that is economically grown in semi-arid and arid areas throughout the world. Cultivation of date palms is reported back to 5000 BC. Desert regions of the Middle East and North Africa remained main hubs of cultivation since 4000 BC and the natural race of *Phoenix* species proceeded from south-eastern areas to Pakistan. The genus *Phoenix* has nearly 400 species in Arecaceae (Palm family). Dates possess high value due to the reason that they provide ample food in very harsh climatic conditions. One hundred gram dried dates (Tamar) deliver energy (277 kcal), carbohydrates (75 g), protein (1.81 g), fat (0.15 g), potassium (696.0 mg) calcium (64.0 mg), phosphorus (62.0 mg) iron (0.90 mg), sodium (1.0 mg), magnesium (54.0 mg), zinc (0.44 mg), copper (0.362 mg), manganese (0.296 mg), thiamine (0.050 mg), vitamin A (149 IU), riboflavin (0.060 mg), pyridoxine (0.249 mg), pantothenic acid (0.805 mg) and niacin (1.610 mg) (USDA National Nutrient Database, 2019).

The date palm is known as a blessed tree due to its various benefits and roles in maintaining environmental equilibrium with growth under harsh climate and highly saline sandy soil. Moreover, due to its large size, it can absorb considerably higher carbon dioxide than many other trees, expressing high potential to fight against global warming. In this way it may play a role of world's future lungs like Amazon's rainforest and transform emissions of carbon dioxide into oxygen and food (Sharif et al., 2010). Date palm is considered as important for economics at Biskra Oasis due to its major role in creating favorable microclimate for horticultural development by screen shielding the influences of desert oasis (Tarai et al., 2014).

On the production side, date fruit needs extended hot summer temperature to get maturity. Under heavy rains or high humidity, its fruit can ferment due to fungal diseases or insects as a result of prevailing humidity. Ideal climate for this species contains a lengthy summer with temperatures at maximum limit (10-40ºC) during day and night as well as dry winters with sunny days and without frosty nights. Climate change resulted in water shortages as well as increase in plant diseases, ultimately decreasing the income from date palm in the Middle Eastern countries (Zaid & Arias Jimenez, 2002). Reduced production under climate change may be further intensified by date palm biology i.e., dioeciousness, mode of pollination and varying fruit maturity (Shabani et al., 2016). During 2008, many farmers from Saudi Arabia observed early flowering of date palm due to climate change (Darfaoui & Assiri, 2009). Results from two global climate models to evaluate the effects of climate change on the distribution of date palm showed a substantial decline may be observed in climatic suitability of cultivation of date palm in Saudi Arabia by 2100 (Allbed et al., 2017).

A climate modelling-based study showed that Iran, Iraq and Saudi Arabia would be most affected by climate change (Shabani et al., 2015). Almost 68% of current cultivable area (129 million hectares) will be unsuitable by 2100 in Saudi Arabia. While 33% of the currently unsuitable area (13 million hectares) of Iran would become suitable by 2100 (Shabani et al., 2014a). Moreover, western Syria, Jordan and Israel would be more suitable for date palm cultivation by 2050 (Shabani et al., 2012; Shabani et al., 2014b). Study at Biskra Oasis for 23 years (1990 - 2013) showed that climate change affected the seasonal distribution of rainfall as most of rainfall occurred in the winter (39.24%) and autumn (37.43%) during the last decade of the 20th century, while most rainfall occurred in spring (37.12%) and winter (33.31%) during the end of the first decade of this century (Tarai et al., 2014). Date palm has been successfully acclimatized in climatic regimes having more than 16°C average surface temperature, such as eastern Pakistan south-eastern Iraq, (Hassan et al., 2006), Southern Iran (Tengberg, 2012) and northern and central Algeria (Saadi, 2006; Elshibli et al., 2009).

Some areas of Pakistan which are currently viable for date production in compatible climates may face unsuitability for date cultivation in future under severe consequences of climate change. Already, it is not grown in Pakistan according to climatically suitable range; the consequences of climate change may further intensify the situation (Farooq et al., 2021). Pakistan is frequently exposed to natural calamities as well as socio-economic stresses in the form of hunger, brain drain due to unwise policies and severe after-effects of global climate change. The susceptibility of agriculture farming to climatic impact is more eminent as the country is more vulnerable on account of dependency mainly over agricultural output. Consequently, due to seasonal changes biophysical relationships would alter water need, edaphic features, biotic and abiotic factors adversely contributing in low agriculture production (Mustafa, 2011). So, management strategies should be made by decision makers that address effects of climate change on agricultural productivity in order to accomplish long lasting sustainable production of cash crops such as date palm.

However, Pakistan has also a significant role in production and export of dates. Pakistan ranks at the 1st position in export of processed (boiled) dates locally called "Chohara" in the world. Pakistan produced 420127 tonnes dates over an area of 99032 hectares during 2018-19. Sindh contributes 44% share in production with 186359 tonnes from an area of 38971 hectares. Balochistan contributes 43% share in production with 181523 tonnes from an area of 53400 hectares. Punjab contributes 9% share in production with 37674 tonnes over an area of about 4876 hectares. Moreover, KPK contributes 3.5% share in production with 14571 tonnes from an area of 1785 hectares (Fruits, Vegetables & Condiments, 2020). National date production was 540606 tonnes during 2017-18 which reduced to 420127 tonnes during 2018-19 with about 22.3% decrease over previous year. Similarly, Sindh province produced 309696 tonnes dates during 2017-18 as seasonal (Monsoon) rainfall was largely deficient over southern Pakistan region (Sindh & Balochistan) and slightly below normal elsewhere (CDPC Technical Report No. 2, 2018). Whereas, 40% decrease in production was recorded during 2018-19 because during monsoon (Jul-Sep) season 2019, the seasonal rainfall was close to normal over Balochistan, while it remained above normal in Sindh province (CDPC Technical Report No. 2, 2019). The major reason could be above normal rains during Monsoon 2019 due to climate change which badly hit the date crop in Sindh province. In the Punjab province of Pakistan rainfall per annum has gone up to 228 mm, whereas monsoon rainfall up to 111.2 mm and winter rainfall up to 59.6 mm during 1901-2007 (Chaudhry et al., 2009) which indicate alarming situation for date palm cultivation in Punjab province. As for date palm concern, the after-effect of changing climate has diverted the attention of researchers to search for such date cultivars which would be rain-tolerant at the ripening stage. Rainfall may affect pollination as well as fruit setting**.** Post- pollination rainfall may wipe out the major quantity of pollen. Therefore, date growers would have to repeat pollination. Rainfall accompanied by low temperature causes a negative effect on fruit set. Pre-pollination drizzling in spring followed by increased atmospheric temperature and humidity may cause inflorescence rot. In many date growing regions of the world, rainfalls match with the ripening time and cause low quality fermented fruit. Quantity of precipitation, prevailing humidity and wind during fruit ripening and maturity decide the future income from date crop (Bashir et al., 2015). There is minimized decay of dates at early ripening stage (Khalal) as fruit is benefited from wiping away of dusty and sandy materials from the fruit surface. Initial ripening stage (Kimri) and late Khalal stage of fruit may result in fruit immaturity and splitting. Prevailing environment, intensity and compatibility of rainfall may decide its suitability at a particular ripening stage. If the weather is clean and winds blow after heavy rainfalls; then damage is minimum compared to the lengthy cloudy weather as a result of continuous light rains (Zaid & de Wet, 2002).

Changing climatic parameters affect the normal plant growth, flowering, fruit development and quality fruit production. Phenology and geographic distribution of date palm is also under effect of recent climate change. Date palm growers may face changing climate by adapting farm innovation, novel plant selections, altering crop patterns and manipulating latest technology to minimize the influence by developing rain-tolerant date cultivars to adapt conditions with judicious management of resources as a major strategy to meet the challenge. The current study is also an endeavor keeping in view climate change impact and economical production of date palm for promotion of future date palm industry in Pakistan.

Materials and Methods

Various date palm strains with better adaptability and elite characteristics (better quality and yield) were collected and planted at Bahawalpur in the past for future research and evaluation. Distribution of monsoon rains has been changed due to changing global climate which is a threat to date fruits that ripen during the same duration. Fermented and inferior quality fruit results in a little yield and very low income or total crop failure. Present study was initiated to explore the after-effects of environmental changes, especially rainfalls in autumn season along with raised temperature adversely affecting the productivity and fruit quality of indigenous date germplasm. Current experiment was conducted during 2017-19 on 12-year old sixty plants which were healthy, vigorous, uniform sized, productive, insects & disease free from twenty cultivars of Date palm planted on date orchards of Horticultural Research Station, Bahawalpur situated at 105m height, 71.64°E longitude, 29.38°N latitude) keeping plant to plant and row to row distance of 20 feet spaced in square formation under climatic conditions prevailing in the southern part of Punjab province (Pakistan). Plants were planted in randomized complete block design with 3 replications of twenty treatments i.e., 20 cultivars viz Hallawi, Makran, Dhaidi, Shakri, Gajjar, Sanduri, Sufaida, Khudrawi, Shamran, Zirin, Zahidi, Aseel, Kupra, Fasli, Pathri, Halwain, Khurma, Dhaki, Bagum jangi and Haleeni. Each experimental unit was supplied with equal nutrition, plant protection and other farm practices like irrigation, fertilizers, pollination, harvesting etc. during the experimental period. Data on quantitative and qualitative characters i.e., palm height (m**),** frond length (m), fermented fruit (%), yield per plant (kg) at Khalal, Tamar and Chohara stages; return (Pakistani Rupees) per plant from Khalal, Tamar and Chohara produce. Plant height and frond length were measured by using measuring tape; fermented fruit percentage was estimated by counting number of fermented fruit and total fruits per plant using the formula as under.

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

Per plant yield (kg) has been estimated by summing up yield during doka stage from total pickings, yield of Tamar (kg) per plant was measured after dehydrating or desiccating the fruit collected during Doka or Rutab stage; yield of Chohara (kg) per plant was calculated from fruit collected at Doka or Rutab stage then boiled and dried to make Chohara. Meteorological data comprising of monthly temperature (maximum and minimum ºC), humidity (%), rainfall (mm) for 3 years (2017-2019) as well as for previous 3 years (2014-2016) to compare the climate change were recorded from observatory of Regional Agricultural Research Institute, Bahawalpur.

Data collected on each parameter were put under analysis of variance (ANOVA) by applying software Statistix 8.1 and comparison of treatment means differences was done by Duncan Multiple Range test (DMRt) at 0.05 probability (Steel et al., 1997) for individual year as well as pooled means from 3 years. Minimum value, maximum value, overall mean with standard deviation and coefficient of correlation among various parameters were calculated from collective data of 20 date cultivars by using computer software Statistical Tool for Agricultural Research (STAR) version 2.0.1.

Results and Discussion

Plant height

Maximum average plant height (4.7 m) was recorded by Khurma that was statistically alike to Dhaidi (4.6 m), Aseel (4.5 m), Zahidi & Dhaki (4.4 m). Gajjar, Kupra and Haleeni shared similar plant height (4.2 m) and were statistically same with plant heights of Halawi & Shakri (4.1 m), and Halwain (4.0 m). The later was the same plant height as Sufaida, Pathri & Bagum jangi (3.9 m) and that of Zirin (3.8 m). All other cultivars ranged from minimum plant height as noted in Sanduri & Shamran (3.4 m) which shared statistical similarity with Khudrawi & Fasli (3.5 m), and the later both were at par with plant height (3.6 m) of Makran (Table 1). Plant height is a visual indicator of suitability and adaptability of climate. Terminal buds or phyllophor boost the vertical growth of date palm and palm can grow up to 20 metres high. Whereas, nutritional deficiency may cause abnormal growth from these terminal buds accompanied by drought conditions which further add to shrinkage of the trunk ((Zaid & de Wet, 2002). Pattern of annual distribution of rainfall could be diverse on account of changing climate (Tarai et al., 2014) due to which some date palm growing regions may face drought conditions in case of less rains or floods in case of heavy rains and palm height predict the adaptability of a cultivar under such changing climate regimes.

Frond length

Average maximum frond length (4.2 m) was recorded by Khurma, followed by Kupra (4.1 m). The later was statistically similar to Dhaidi & Dhaki (4.0 m). Shakri and Aseel both had 3.9 m frond length, but statistically alike to Dhaidi & Dhaki. Makran, Gajjar, Khudrawi & Zahidi with the same frond length (3.8 m) remained at par with Shakri & Aseel. Halawi, Halwain & Bagum jangi with 3.7m frond length were statistically similar to previous cultivars having 3.8 m frond length. Sufaida & Haleeni (3.6 m) were statistically alike to cultivars with 3.7m frond length. Zirin & Pathri with the same frond length (3.5 m) were similar to Sufaida & Haleeni. Fasli had 3.4m frond length and was statistically the same with the frond length of Zirin & Pathri. Shamran with minimum frond length (3.3 m) was at par with that of Fasli (Table 1). Frond length is a good indicator of growth and productivity of plants under the climate of a certain area, more frond length carry more number of pinnae (leaflets) that produce carbohydrates under photosynthesis for fruit and fruit related attributes. Although, rainfall and high humidity is deleterious to fruit, yet beneficial for growth of frond length depending upon the type of cultivar, soil nutritional status and other climatic factors. High rains during summer (July-September) and rainless duration (October-December) in southern part of the Sahara Desert (Sahel), extended date palm cultivation exceptionally (Tarai et al., 2014). Length of date palm frond could reach 3-6 m with an average of 4 m depending upon cultivar, age of palm and prevailing climate. Fronds have a normal life of 3 to 7 years and its structural development varies according to agro-climatic conditions, but in a conducive environment a frond can help in producing 1 - 1.5 kg of dates (Zaid & de Wet, 2002).

Fermented fruit percentage

Minimum fermented fruit (21%) was recorded by Bagum jangi, followed by Zirin (22%) and Haleeni (23%). These three were statistically similar to each other. The later shared statistical similarity to Dhaki (24%) & Shakri (25%) that was at par with Halwain (26%), Halwain was similar to Halawi (28%) that was statistically alike to Khurma (30%) and it remained at par with Sanduri (31%) & Gajjar (32%). The later both were similar to Sufaida & Zahidi both with 33% fermented fruit and remained at par with Aseel (34%) & Makran (35%). The later were statistically alike to Shamran (36%) & Dhaidi (37%) and both were statistically similar to Pathri (38%) which was at par with Fasli (40%). Maximum fermented fruit (48%) was recorded by Khudrawi, followed by Kupra (43%) as presented in Table 1. Date cultivation is prominent in those regions which receive winter rainfall to the extent not harmful to date fruit, but helpful in leaching the salts accumulated in the upper surface and slow down the movement of salts from soil under surface to upper surface. Most of the date-growing countries remain devoid of rains till November where harvesting start from middle of August to end October. Prevailing the rainy season at emergence of flowers is less harmful than that of fruit harvesting which might result in some economic fruit loss (Zaid & de Wet, 2002). The chances of crop damage by rains in Monsoon months (July- September) in any given season are more important. Quantity of rain is not important when compared with its occurrence in a particular prevailing weather. A drizzling for a long period or wet conditions under clouds are likely to destroy the fruit severely as compared to high rains preceded by clean sky and aeration (Zaid & de Wet, 2002).

Khalal (Doka) yield

Maximum yield of Khalal (doka) dates per plant (120 kg) was achieved by Zahihi, followed by Aseel (115 kg), Halawi (109 kg), Khurma (101 kg), Dhaki (94 kg) and Haleeni (90 kg) cultivars. All these cultivars are best in yield of Khalal dates. Makran (85 kg), Gajjar (84 kg), Kupra (83 kg) and Dhaidi (82 kg) were statistically aike in Khalal yield. Bgum jangi (79 kg), Khudrawi (78 kg), Shakri (77 kg) & Sufida (75 kg) were at par with each other. The later shared statistical similarity with Shamran (74 kg) & Sanduri (73 kg) that was statistically alike to Halwain (72 kg) & Zirin (71 kg). The cultivars which ranged in Khalal dates from 71 kg to 85 kg could be considered good cultivars for consuming at Khalal stage. Zirin was also statistically similar to Fasli (69 kg) in Khalal yield. Pathri attained the minimum Khala yield (64 kg) per plant. Fasli and Pathri cultivars would be optional for date growers because these cultivars are very tasty at Khalal stage (Table 2). It is worth mentioning that date fruit at early Khalal is at less risk, rather it is benefited in the form of clean, dust-free fruit by washing of rain water. Fruit at initial growth (Kimri) and at late ripening (Khalal) is subjected to adverse effect in the form of retarded fruit or cracked fruit (Zaid & de Wet, 2002). During colonial period of sub-continent, a few Arabian date palm varieties from Basra (Iraq) i.e., Halawi, Khudrawi, Shamran (Sayer), Zahidi and Zirin were planted at Multan and Muzaffargarh (Punjab, Pakistan) during 1910-12. Halawi which is consumed at Khalal stage became an important income source in date industry of Punjab, Pakistan due to wet conditions during fruit maturity resulting into limited plantation of date cultivars as date palm culture is well developed in dry climatic regions and its sustainability is controlled by various climatic limitations (Ata et al., 2012). Aseel cultivar is not favoured as a Khalal cultivar because of high tannin contents. Instead, it is eaten in Rutab and prepared as Tamar for market (Markhand et al., 2010). In Pakistan, average fruit yield per date palm is reported to be about ninety kilogram per palm, half of which is wasted through monsoon rains, wind storms and parrots. That is why net produce is reduced to the maximum (Fatima et al., 2016).

Tamar yield

Maximum Tamar yield per plant (102 kg) was recorded by Zahidi, followed by Aseel (97 kg). Halawi ranked 3rd with 79 kg and remained at par with Khurma (78 kg). Haleeni (74 kg), Dhaki (73 kg) & Gajjar (72 kg) were statistically alike in Tamar yield. The later was statistically similar to tKupra (69 kg), Shakri (68 kg) & Dhaidi (67 kg) and Dhaidi was alike to Makran (66 kg) in Tamar yield. Sanduri had 65 kg Tamar yield and was statistically similar to Sufaida (63 kg) which remained at par with Khudrawi (62 kg) and it was similar to Bagum jangi (60 kg) which further shared statistical similarity with Shamran (59 kg) & Halwain (58 kg). The last was similar to Zirin (56 kg). Significantly minimum Tamar yield 49 kg per plant was attained by Pathri cultivar (Table 2). Early rainfall at flowering may result in low fruit set and late rainfall may cause fermentation of date at Rutab and Tamar stages as heavy losses in the form of dropped and rotten fruit due to high wet conditions created by atmospheric humidity and low temperature that may delay ripening and harvesting. However, Aseel cultivar is a good performer at Tamar stage and is very appropriate for use of Aseel as a Tamar. Similarly, a major group of Pakistani date cultivars belongs to the semi-dry (Tamar) category, of which maximum are vulnerable to summer rainfall because of synchronization with the time of ripening and harvesting (Markhand et al., 2010). However, it is suggested to process the dates by traditional drying under sun or preserving the date fruit in cold storages, thereby enhancing the shelf-life for distant markets (Naqvi et al., 2015).

Chohara yield

Maximum yield of Chohara per plant (87 kg) was obtained by Aseel, followed by Zahihi (85 kg). Halavi ranked 3rd (72 kg), followed by Khurma (70 kg). The later two cultivars were the same statistically and Khurma further remained statistically at par with Dhaki (68 kg). Haleeni (65 kg) remained at par with Gajjar (64 kg) that was statistically similar to Kupra (62 kg) and Kupra shared similarity with Makran (61 kg) & Shakri (60 kg). The later was statistically similar to Sanduri (59 kg) & Dhaidi (58 kg) cultivars. Halwain (55 kg), followed by Khudrawi (54 kg) & Sufaida (53 kg) cultivars were statistically similar. Similarly, Shamran (52 kg), Bagum jangi (51 kg) & Zirin (50 kg) cultivars were statistically at par with each other. The later was also statistically alike to Fasli (48 kg) cultivar. The minimum chohara yield per plant (44 kg) was obtained by Pathri cultivar. All cultivars having chohara yield more than 60 kg per plant may be considered as good and those which ranged from 50 to 59 kg as satisfactory. Those cultivars which have less than 50 kg chohara yield per plant are not economically suitable for making chohara and sale in the market (Table 2). Drizzling or prevailing wet cloudy seasons for a long duration is more harmful when compared with clean weather accompanied by dry air blowing (Zaid & de Wet, 2002). It was previously documented that date cultivars are diverse in response to rainfalls and prevailing humid conditions such as Dayri, Khastawi, Thoory, Khadraoui, and Sair under Coachella Valley climate remained the most tolerant to rains out of sixteen date cultivars, while Zahidi, Khalas and Barhee with medium resistant, and Deglet Nour, Yatima, Hayani and Ghars with maximum susceptibility to rainfalls. Early varieties of Iran (Al- Mehtari) and late varieties of Iraq (Khissab and Hilali) tolerate rains very well as a result their fruiting is not influenced by rains. Hence, a number of Aseel farmers prefer to pick the fruit in Khalal form and convert the fruit into "Chuhara" by boiling. Otherwise, maximum produce may be wasted under the influence of summer rains (Markhand et al., 2010).

Return from Khalal

Maximum average return per plant from Khalal dates (Rs. 3033) was obtained from Khurma, followed by Halawi (Rs. 2900) both remained statistically at par with each other. Dhaidi (Rs. 2817) & Makran (Rs. 2767) ranked 3rd & 4th respectively. Both were statistically at par with Halawi in return from Khalal dates. These four cultivars performed the best in the Southern Punjab climate regime. All other cultivars ranged in return at Khalal stage from Rs. 1583 (cv. Fasli) to Rs. 2600 (cvs. Aseel & Haleeni). Fasli, Pathri (Rs. 1787) & Zirin (Rs. 1917) are not suitable to get reasonable return per plant at Khalal stage in Southern Punjab climate regime (Table 3). Early-ripening date varieties fetch more economic return than that of the mid-ripening date varieties and economic value is also specific with respect to date variety in UAE (Abul-Soad, 2011). Socio-economic status, role of date cultivation as a food in core date production regions of Pakistan is not reported properly. Poverty can be alleviated in date growing areas of Pakistan by providing the agro-mechanic facilities on farmer’s fields to exploit efficient post-harvest techniques and proper disposal of date produce. While, restrictions in date growing regions of Pakistan contain low-yielding poor quality date cultivars, lacking farm practices, un-availability of grading, processing and packing facilities, price fluctuation at the time of date fruit disposal and lack of experienced man power (Fatima et al., 2016). Labour for picking and harvesting of dates is paid from part of produce. Harvesting of date at Khalal (doka) is a first stage of picking and very beneficial to engaged labour in terms of return if a cultivar is early maturing and good yielder like Khurma and Halawi giving maximum return not only to the farmers but also to the engaged labour under prevailing climate.

Return from Tamar

Maximum average return per plant from Tamar dates (Rs. 3800) was obtained by Aseel cultivar, followed by Zahidi (Rs. 3683) & Dhakki (Rs. 3600). These cultivars were statistically at par with each other. Khurma (Rs. 3400) & Halawi (Rs. 3267) were also reasonable options to get return from Tamar. All other cultivars ranged from Rs. 1540 (cv. Fasli) to Rs. 2900 (cv. Haleeni). Fasli, Pathri (Rs. 2033), Khudrawi (Rs. 2133) & Zirin (Rs. 2167) cultivars are not suitable to get return by making Tamar under Southern Punjab climate regime (Table 3). Phyto-pathogens and drought conditions have reduced annual economic return from date cultivation due to changing agro-climatic scenarios in the Middle East during 1990-2000 (Zaid & Arias Jimenez, 2002). In Pakistani Market (Sukkur, Sindh) price of Aseel reached from normal price (in October) to the maximum (in December) for cured dates (Abul-Soad, 2011). Fatima et al. (2016) reported that most date growers faced adverse consequences from summer rainfall at the time of fruit ripening (June–October) by creating epicarpal cracks in date fruit only within 2-3 days. They are forced to dry dates under sunlight as an alternative recovery from non-available drying and processing facilities. Similarly, many date growers reproduced date plants from their own varietal offshoots lacking quality characters instead of elite date germplasm for quality productivity. Cultivars fetching good returns from Tamar like Aseel, Zahidi and Dhaki under prevailing climate would be the best choice for future date industry in Pakistan.

Return from Chohara

Maximum average return of Chohara dates per plant (Rs. 4053) was attained by Aseel cultivar, followed by Dhakki (Rs. 3845) & Zahidi (Rs. 3818). The later two cultivars were statistically at par with each other. Haleeni cultivar could be a good option to get reasonable return (Rs. 3243) from Chohara dates. All other cultivars ranged in return of Chohara from Rs. 2013 (cv. Fasli) to Rs. 3107 (cv. Halawi). Fasli, Pathri (Rs. 2152) & Halwain (Rs. 2315) cultivars are not suitable to get return from Chohara dates (Table 3). Quantity of precipitation, prevailing humidity and wind during fruit ripening and maturity decide the future income from date crop (Bashir et al., 2015). To escape risk of low income, the alternative way is to convert ripe date fruit into boiled fruit (Chohara) for suitable income from varieties producing quality Chohara fruit like Aseel, Dhaki and Haleeni etc. The range of dried dates is maximum in Pakistani Market (Sukkur, Sindh) to process date fruit in the form of 'Chohara' by boiling Khalal dates (Abul-Soad, 2011). Therefore, many growers of Sindh province harvest fruit of Aseel cultivar during Khalal form and boil the date fruit to convert into "Chuhara". Otherwise, whole produce may destroy and result in economic loss if monsoon rains occur (Makhand et al., 2010).

Overall minimum, maximum and mean±SD values of parameters

Plant height ranged from 3.4-4.7m with mean & standard deviation (4.01±0.40), frond length from 3.2-4.2m with mean & SD (3.73±0.26), fermented fruit percentage from 21-48% with mean & SD (32.0±7.27), Khalal yield per plant from 64-120kg with mean & SD (85.0±15.7), Tamar yield per plant from 49-102kg with mean & SD (68.5±13.3), Chohara yield per plant from 44-87kg with mean & SD (60.9±11.4), Return of Khalal dates from Rs. 1583-3033 with mean & SD (2296±396), Return of Tamar dates from Rs. 1540-3800 with mean & SD (2649±612), Return of Chohara dates from Rs. 2013-4053 with mean & SD (2857±556) as apparent from Table 4.

Correlation among various parameters

Coefficient of correlation among various parameters under study showed that all parameters were positively correlated with each other except fermented fruit percentage. All parameters were negatively correlated with fermented fruit percentage except frond length (Table 5). It seems that frond length may have a role in infestation / fermentation of fruit being carrier of fungi inoculum according to length of frond.

Meteorological data

More than 100% increase in rainfalls has been noted during pollination months (February-April) over the previous 3 years. It may affect pollination, fertilization and fruit setting in Date palm. Intensity of rainfalls has increased in May (45%), June (92%), July (47%) and August (68%) than previous 3 years, accompanied by more than 10% increase in atmospheric humidity during these 4 months. Increase in rainfalls and increase in atmospheric humidity are affecting date fruit by causing fermentation of fruit in all kinds of varieties going to ripening in early ripening (June), mid-ripening (July) or late ripening (August) etc. Intensity of rainfalls in September has decreased (72%) compared to the previous 3 years. It seems very favorable for late-season ripening cultivars e.g., Dhaki and Haleeni and necessitates further efforts in search of late varieties from indigenous and exotic date palm germplasm for South Punjab region. Intensity of rainfalls during October to December has increased more than 1000% compared to the previous 3 years, it suggests that planting of date palm during October-November will be suitable in future and after planting some water requirements would be compensated also by rainfall water. June, 2017 received maximum precipitation (102 mm) of the year than that of the past years precipitation in the month of June which might be harmful to early ripening date cultivars i.e. Gajjar, Shakri, Halawi and Makran. Many cultivars are mid-season and remain always vulnerable to monsoon rainfalls and usually have more fermented fruit compared to early and late varieties. Next year July, 2018 received the maximum precipitation (128 mm) of the year to hit the mid-season date cultivars badly.

Similarly, August, 2018 received the next highest rainfall (84 mm) of the year and August, 2019 received the highest rainfall (96 mm) of the year. Both years indicated that cultivars going to ripe in August (late mid-season) might be vulnerable to August rainfalls in future. However, date cultivars which ripe in September (Dhaki & Haleeni) are safe from the damage because September of three years received 0, 02 and 16 mm rainfall respectively. Rainfalls at the time of flowering and pollination occurred during February (53 mm) and March (41 mm) during 2019 is a caution for future years to be vigilant with respect to flowering and pollination of date pam. Total fruit production season of date palm prevails from 180 to 210 days from fruit setting till fruit maturation. However, rainfall at Khalal (mature fruit) is susceptible to rains but Rutab and Tamer (ripe fruit) are more vulnerable to rains. Monsoon rainfall (July-August) is a serious issue not only for on-tree fruit but also for fruit subjected to curing under sun. Date farmers may choose alternative practices to process date fruit under controlled conditions of processing chambers or dehydrators. When fruit moisture is below 24%, there is better chance to dehydrate Rutab fruit into Tamar form, but in operation at the time date fruit ripening ample dehydrators are not available to process a huge quantity of dates produced in Pakistan (Abul-Soad, 2011). Information sharing, awareness creating, skill improving, altered policies, promulgating of estimate plans required to refresh all stakeholders such as date palm growers, trend setters and researchers to face impact of climate change with respect to date palm.

Conclusion

Climate of southern Punjab is suitable for date production but changing climate may hinder the best quality production. Current study revealed that summer precipitation as well as heat stress may affect the productivity and quality of indigenous genepool of Date palm. June is going to be more humid and riskier for early ripening date cultivars in comparison with past years. Economically, Khurma, Halawi, Dhaidi and Makran cultivars are the best cultivars for the Dhoka stage; Aseel, Zahidi, Kupra and Dhaki cultivars are very good for making Tamar. Aseel, Dhaki Haleeni cultivars are best suited to convert fruit at doka stage into Chohara (boiled/dry date) not only to make up expected loss due to rains but maximum return from Choharas in South Punjab region. Meteorological data expressed more than 100% increase in rainfalls during pollination months (February-April), more than 60% increase in rainfalls during fruit ripening months (May-August) alongwith more than 10% increase in atmospheric humidity during these 4 months over previous 3 years.

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Table 1 Plant height, frond length and fermented fruit as affected by climate regime in date palm

Cultivars	Plant height (m)				Frond length (m)				Fermented fruit (%)			
	2017	2018	2019	*Mean	2017	2018	2019	*Mean	2017	2018	2019	*Mean
V_1=Halawi	3.7^{cd}	4.0^{cd}	4.5^{ef}	4.1^{cd}	3.6^{e}	3.7^{f}	3.9^{ef}	3.7^{ef}	31^{de}	33^{h}	21^{j}	28^{jk}
V_2=Makran	3.3^{ef}	3.5^{e}	4.0^{g}	3.6^{e}	3.6^{e}	3.8^{e}	3.9^{ef}	3.8^{de}	36^{c}	39^{ef}	30^{fg}	35^{efg}
V_3=Dhaidi	4.2^{ab}	4.6^{a}	5.0^{ab}	4.6^{a}	3.9^{b}	4.0^{c}	4.1^{cd}	4.0^{bc}	29^{efg}	41^{de}	40^{b}	37^{de}
V_4=Shakri	3.8^{c}	4.1^{c}	4.5^{ef}	4.1^{cd}	3.8^{c}	3.9^{d}	4.0^{de}	3.9^{cd}	21^{ij}	29^{i}	26^{i}	25^{lm}
V_5=Gajjar	3.7^{cd}	4.2^{bc}	4.6^{de}	4.2^{c}	3.7^{d}	3.8^{e}	4.0^{de}	3.8^{de}	30^{ef}	36^{g}	29^{gh}	32^{hi}
V_6=Sanduri	3.1^{f}	3.4^{e}	3.8^{h}	3.4^{f}	3.0^{j}	3.2^{k}	3.3^{j}	3.2^{j}	24^{h}	40^{de}	27^{hi}	31^{i}
V_7=Sufaida	$3.6d^{e}$	3.9^{d}	4.3^{f}	3.9^{d}	3.4^{g}	3.6^{g}	3.8^{fg}	3.6^{fg}	28^{fg}	42^{cd}	29^{gh}	33^{ghi}
V_8=Khudrawi	3.2^{ef}	3.5^{e}	3.9^{gh}	3.5^{ef}	3.7^{d}	3.8^{e}	4.0^{de}	3.8^{de}	51^{a}	55^{a}	31^{fg}	48^{a}
V_9=Shamran	3.1^{f}	3.4^{e}	3.8^{h}	3.4^{f}	3.2^{i}	3.3^{j}	3.4^{j}	3.3^{ij}	30^{ef}	46^{b}	32^{ef}	36^{def}
V_{10}=Zirin	3.4^{ef}	3.8^{d}	4.2^{f}	3.8^{de}	3.4^{g}	3.5^{h}	3.7^{gh}	3.5^{gh}	20^{jk}	25^{jk}	20^{j}	22^{no}
V_{11}=Zahidi	3.9^{bc}	4.4^{ab}	4.8^{bc}	4.4^{b}	3.7^{d}	3.8^{e}	3.9^{ef}	3.8^{de}	29^{efg}	36^{g}	34^{de}	33^{ghi}
V_{12}=Aseel	4.1^{ab}	4.5^{a}	4.9^{b}	4.5^{ab}	3.6^{e}	3.8^{e}	4.1^{cd}	3.9^{cd}	31^{de}	37^{fg}	35^{d}	34^{fgh}
V_{13}=Kupra	3.8^{c}	4.2^{bc}	4.7^{cd}	4.2^{c}	4.0^{a}	4.1^{b}	4.2^{bc}	4.1^{ab}	39^{b}	47^{b}	44^{a}	43^{b}
V_{14}=Fasli	3.2^{ef}	3.5^{e}	3.9^{gh}	3.5^{ef}	3.3^{h}	3.4^{i}	3.5^{ij}	3.4^{hi}	38^{bc}	44^{c}	36^{c}	40^{c}
V_{15}=Pathri	3.5^{de}	3.9^{d}	4.3^{f}	3.9^{d}	3.3^{h}	3.4^{i}	3.6^{hi}	3.5^{gh}	33^{d}	43^{c}	38^{bc}	38^{cd}
V_{16}=Halwain	3.6^{d}	4.0^{cd}	4.5^{ef}	4.0^{cd}	3.5^{f}	3.6^{g}	3.8^{fg}	3.7^{ef}	20^{jk}	32^{h}	26^{i}	26^{kl}
V_{17}=Khurma	4.3^{a}	4.6^{a}	5.1^{a}	4.7^{a}	4.0^{a}	4.2^{a}	4.4^{a}	4.2^{a}	27^{g}	33^{h}	30^{fg}	30^{ij}
V_{18}=Dhaki	4.0^{ab}	4.4^{ab}	4.9^{b}	4.4^{b}	3.9^{b}	4.0^{c}	4.1^{cd}	4.0^{bc}	23^{hi}	27^{ij}	22^{j}	24^{lmn}
V_{19}=Bagum jangi	3.5^{de}	3.8^{d}	4.3^{f}	3.9^{d}	3.5^{f}	3.7^{f}	3.9^{ef}	3.7^{ef}	18^{k}	24^{k}	21^{j}	21^{o}
V_{20}=Haleeni	3.8^{c}	4.2^{bc}	4.7^{cd}	4.2^{c}	3.3^{h}	3.6^{g}	3.8^{fg}	3.6^{fg}	22^{hij}	28^{i}	20^{j}	23^{mno}

Means sharing similar letter (s) in a column under each parameter are statistically non-significant as compared by DMR test at α=0.05

Table 2 Yield from Khalal (Doka), Tamar (Pind) and Dried (Chohara) per plant as affected by climate regime in date palm

Cultivars	Yield (Khalal/ Doka)/ plant (kg)				Yield (Tamar/ Pind)/ plant (kg)				Yield (Dried/ Chohara)/ plant (kg)			
	2017	2018	2019	*Mean	2017	2018	2019	*Mean	2017	2018	2019	*Mean
V_1 = Halawi	100^{c}	108^{c}	120^{c}	109^{c}	72^{c}	76^{d}	89^{b}	79^{c}	65^{b}	70^{cd}	81^{c}	72^{c}
V_2 = Makran	80^{e}	84^{g}	93^{g}	85^{g}	63^{ef}	66^{h}	69^{i}	66^{fg}	58^{de}	60^{fg}	65^{hi}	61^{g}
V_3 = Dhaidi	75^{fg}	80^{gh}	91^{gh}	82^{g}	61^{fg}	68^{g}	72^{gh}	67^{ef}	53^{ij}	58^{gh}	64^{ij}	58^{h}
V_4 = Shakri	73^{gh}	76^{hi}	82^{jk}	77^{h}	62^{f}	64^{ij}	78^{d}	68^{ef}	55^{gh}	57^{hi}	67^{gh}	60^{gh}
V_5 = Gajjar	79^{ef}	81^{gh}	92^{gh}	84^{g}	64^{e}	70^{ef}	82^{cd}	72^{de}	57^{ef}	63^{f}	73^{f}	64^{ef}
V_6 = Sanduri	70^{gh}	73^{ij}	76^{mn}	73^{ij}	60^{fg}	65^{hi}	70^{hi}	65^{gh}	52^{jk}	59^{gh}	66^{gh}	59^{h}
V_7 = Sufaida	69^{ghi}	75^{hi}	81^{k}	75^{hi}	59^{g}	63^{j}	67^{j}	63^{hi}	51^{kl}	53^{jk}	55^{n}	53^{ij}
V_8 = Khudrawi	72^{gh}	77^{hi}	85^{ij}	78^{h}	52^{hi}	60^{k}	74^{fg}	62^{ij}	47^{mn}	52^{kl}	63^{jk}	54^{ij}
V_9 = Shamran	67^{ij}	72^{ij}	83^{jk}	74^{i}	50^{hi}	59^{k}	68^{ij}	59^{k}	45^{no}	51^{kl}	60^{lm}	52^{jk}
V_{10} = Zirin	68^{hij}	71^{j}	74^{o}	71^{jk}	53^{h}	55^{l}	60^{k}	56^{l}	46^{no}	50^{lm}	54^{n}	50^{kl}
V_{11} = Zahidi	110^{a}	121^{a}	129^{a}	120^{a}	97^{a}	104^{a}	105^{a}	102^{a}	82^{a}	85^{b}	88^{b}	85^{b}
V_{12} = Aseel	105^{b}	115^{b}	125^{b}	115^{b}	90^{b}	98^{b}	103^{a}	97^{b}	80^{a}	89^{a}	92^{a}	87^{a}
V_{13} = Kupra	78^{ef}	83^{g}	88^{hi}	83^{g}	65^{e}	69^{fg}	73^{fg}	69^{e}	56^{fg}	62^{f}	68^{g}	62^{fg}
V_{14} = Fasli	59^{k}	70^{j}	80^{kl}	69^{k}	49^{ij}	53^{lm}	58^{k}	53^{m}	43^{p}	48^{m}	53^{n}	48^{l}
V_{15} = Pathri	56^{k}	65^{k}	71^{p}	64^{l}	44^{k}	50^{m}	55^{l}	49^{n}	41^{q}	44^{n}	48^{o}	44^{m}
V_{16} = Halwain	64^{ij}	74^{hij}	78^{lm}	72^{jk}	45^{k}	64^{ij}	66^{j}	58^{kl}	49^{lm}	55^{ij}	61^{kl}	55^{i}
V_{17} = Khurma	91^{d}	102^{d}	110^{d}	101^{d}	66^{de}	81^{c}	88^{b}	78^{c}	60^{cd}	72^{c}	77^{de}	70^{cd}
V_{18} = Dhaki	83^{e}	96^{e}	103^{e}	94^{e}	68^{d}	72^{e}	77^{e}	73^{d}	62^{c}	67^{e}	75^{ef}	68^{d}
V_{19} = Bagum jangi	66^{ij}	82^{gh}	90^{gh}	79^{h}	48^{j}	58^{k}	75^{ef}	60^{jk}	44^{op}	50^{lm}	59^{m}	51^{k}
V_{20} = Haleeni	81^{e}	91^{f}	98^{f}	90^{f}	67^{d}	71^{ef}	84^{c}	74^{d}	54^{hi}	68^{de}	74^{f}	65^{e}

Means sharing similar letter (s) in a column under each parameter are statistically non-significant as compared by DMR test at $\alpha = 0.05$

Table 3 Return (Rs.) from Khalal (Doka), Tamar (Pind) and Dried (Chohara) per plant as affected by climate regime

Cultivars	Return (Khalal / Doka) / plant (Rs.)				Return (Tamar / Pind) / plant (Rs.)				Return (Dried / Chohara) / plant (Rs.)			
	2017	2018	2019	*Mean	2017	2018	2019	*Mean	2017	2018	2019	*Mean
V_1= Halawi	2500^{a}	2900^{a}	3300^{bc}	2900^{ab}	3000^{b}	3200^{c}	3600^{cd}	3267^{d}	2975^{cd}	3015^{c}	3330^{d}	3107^{cd}
V_2 = Makran	2300^{ab}	2700^{ab}	3300^{bc}	2767^{b}	2450de	2650^{e}	2800^{fgh}	2633^{fgh}	2640^{e}	2750^{d}	3000^{e}	2797^{f}
V_3 = Dhaidi	2450^{a}	2700^{ab}	3000de	2817^{b}	2300^{ef}	2400^{f}	2600^{ghi}	2433^{gh}	2440^{f}	2900^{c}	3230^{d}	2857^{ef}
V_4 = Shakri	1800de	2000de	2300^{hi}	2033^{gh}	2200^{fg}	2400^{f}	2550^{hij}	2383^{h}	2360^{fg}	2880^{cd}	3300^{d}	2847^{ef}
V_5 = Gajjar	2050^{c}	2200^{cd}	2400^{gh}	2217^{e}	2600^{cd}	2700de	2850^{f}	2700^{ef}	2840^{d}	2850^{cd}	3040^{e}	2910de
V_6 = Sanduri	2200^{bc}	2400^{bc}	2750^{c}	2450^{d}	2200^{fg}	2300^{fg}	2400^{ij}	2300^{i}	2320^{fg}	2465^{ef}	2660^{gh}	2482^{g}
V_7 = Sufaida	1750de	1900d^{e}	2350^{h}	2000^{gh}	2100^{fg}	2200^{g}	2350^{i}	2217^{h}	2200^{g}	2565^{e}	2930^{e}	2565^{g}
V_8 = Khudrawi	1600^{e}	2200^{cd}	2500^{g}	2100^{fg}	1750^{ij}	2200^{g}	2450^{ij}	2133^{j}	1880^{h}	2550^{e}	2950^{e}	2460^{gh}
V_9 = Shamran	1850de	2050^{d}	2350^{h}	2083^{fg}	2200^{fg}	2300^{fg}	2500^{i}	2333^{h}	2360^{fg}	2535^{e}	2770^{fg}	2555^{g}
V_{10} = Zirin	1750de	1900de	2100^{jk}	1917^{h}	2000^{gh}	2200^{g}	2300^{ij}	2167^{i}	2160^{h}	2315^{fg}	2790^{fg}	2422^{gh}
V_{11} = Zahidi	2000^{c}	2500^{bc}	3100^{cd}	2533^{cd}	3350^{a}	3700^{a}	4000^{ab}	3683^{a}	3520^{b}	3705^{b}	4230^{a}	3818^{b}
V_{12} = Aseel	2200^{bc}	2600^{bc}	3000de	2600^{c}	3500^{a}	3800^{a}	4100^{a}	3800^{a}	3750a	4070^{a}	4340^{a}	4053^{a}
V_{13} = Kupra	2000^{c}	2200^{cd}	2400^{gh}	2200^{ef}	2700^{c}	2900^{d}	3300de	2730^{efg}	2960^{cd}	2970^{e}	3170^{e}	3033^{d}
V_{14} = Fasli	1250^{g}	1500^{f}	2000^{k}	1583^{j}	1540^{k}	1984^{h}	2967^{f}	1540^{k}	1640^{i}	1970h	2430^{i}	2013^{i}
V_{15} = Pathri	1500^{f}	1700^{ef}	2150^{j}	1783^{i}	1750^{ij}	2100^{gh}	2250^{j}	2033^{j}	1840^{h}	2050^{h}	2565^{hi}	2152^{i}
V_{16} = Halwain	1800de	2000de	2300^{hi}	2050^{gh}	1600^{jk}	2500^{ef}	3000^{ef}	2367^{h}	1680^{i}	2250^{g}	3015^{e}	2315^{h}
V_{17} = Khurma	2500^{a}	3000^{a}	3600^{a}	3033^{a}	3000^{b}	3400^{bc}	3800^{bc}	3400^{cd}	2400^{f}	2890^{c}	3975^{b}	3088^{d}
V_{18} = Dhaki	2000^{c}	2200^{cd}	2500^{g}	2233^{e}	3300^{a}	3600^{ab}	3900^{bc}	3600^{abc}	3650^{a}	3815^{b}	4070^{b}	3845^{b}
V_{19} = Bagum jangi	1750de	1900de	2400^{gh}	2017^{gh}	1800^{hij}	2450^{f}	2850^{fgh}	2367^{h}	1880^{h}	2880^{cd}	2985^{e}	2582^{g}
V_{20} = Haleeni	2400^{a}	2600^{b}	2800^{ef}	2600^{c}	2700^{c}	2900^{d}	3100^{e}	2900^{e}	3080^{c}	3050^{c}	3600^{c}	3243^{c}

Means sharing similar letter (s) in a column under each parameter are statistically non-significant as compared by DMR test at $\alpha = 0.05$

Table 4 Minimum, maximum and mean ± SD values of parameters calculated from collective data of 20 date cultivars

Parameters	Minimum	Maximum	Mean ± SD
Plant height (m)	3.4	4.7	4.01±0.40
Frond length (m)	3.2	4.2	3.73±0.26
Fermented fruit %	21	48	32.0±7.27
Yield (Khalal/Doka)/plant (kg)	64	120	85.0±15.7
Yield (Tamar/Pind)/plant (kg)	49	102	68.5±13.3
Yield (Dried/Chohara)/plant (kg)	44	87	60.9±11.4
Return (Khalal / Doka) / plant (Rs.)	1583	3033	2296±396
Return (Tamar / Pind) / plant (Rs.)	1540	3800	2649±612
Return (Dried / Chohara) / plant (Rs.)	2013	4053	2857±556

Table 5 Coefficient of correlation among various parameters (calculated from collective data of 20 date cultivars)

	PH	FL	FF	YK	YT	YC	RK	RT	RC
PH	1.0000	0.7862	-0.2454	0.6417	0.6362	0.6387	0.5334	0.7192	0.7023
FL	0.7862	1.0000	0.0450	0.5010	0.4686	0.4902	0.4673	0.5702	0.5633
FF	-0.2454	0.0450	1.0000	-0.1181	-0.0903	-0.1141	-0.0979	-0.2536	-0.2016
YK	0.6417	0.5010	-0.1181	1.0000	0.9564	0.9569	0.7021	0.9256	0.8851
YT	0.6362	0.4686	-0.0903	0.9564	1.0000	0.9839	0.6446	0.8953	0.9048
YC	0.6387	0.4902	-0.1141	0.9569	0.9839	1.0000	0.6761	0.9273	0.9175
RK	0.5334	0.4673	-0.0979	0.7021	0.6446	0.6761	1.0000	0.6858	0.5808
RT	0.7192	0.5702	-0.2536	0.9256	0.8953	0.9273	0.6858	1.0000	0.9474
RC	0.7023	0.5633	-0.2016	0.8851	0.9048	0.9175	0.5808	0.9474	1.0000

PH = Plant height; FL = Frond length; FF = Fermented fruit%; YK = Yield of Khalal; YT = Yield of Tamar; YC = Yield of Chohara; RK = Return from Khalal; RT = Return from Tamar; RC = Return from Chohara