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Varietal Evaluation of Introduced Date Palm (*Phoenix dactylifera* L.) under Irrigated Condition of Afar Region, Ethiopia

Yitages Kuma Beji and Niguse Chewaka Jiru

Werer Agricultural Research Center, Ethiopian Institute of Agricultural Research
***Corresponding author:** yitagesk@gmail.com

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ABSTRACT

The Date Palm (Phoenix dactylifera L.) is one of the oldest and best-known cultivated fruit trees. The fruit is composed of very nutritive minerals like potassium, calcium, iron, chlorine, phosphorus, and magnesium. The tree can withstand relatively harsh climate and soil conditions, which no other crop can match. In Ethiopia, date palm is cultivated and/or wildly grown in the Afar, Dire Dawa, Somali, Gambella and Benishangul Gumuz regions. However, the yields of local cultivars are too low to meet the sharply increasing demand. Thus, research has been conducted to evaluate and register the best-performing, desirable yield and quality of introduced improved varieties. Fourteen (14) tissue-cultured introduced materials from England and Israel were planted at 10m x 10m spacing between rows and plants over three locations, viz., Werer Agricultural Research Center (WARC), Assiyta, and Afambo districts. Two varieties (Barhee and Medjool), early fruiting types, were individually evaluated out of 12 varieties on the basis of fruit yield for two years at WARC, while vegetative parameters were taken from the other locations. The study revealed that Barhee and Medjool were superior to the remaining date palm varieties. The annual yield advantage of Barhee (68.39 kg tree-^{1}) over Medjool (50.87 kg tree-^{1}) was 34.44%. The high offshoot production potential of Barhee and Medjool varieties could reduce the purchase of imported tissue-cultured date palms by the country as well as individuals. In conclusion, the newly released varieties Barhee and Medjool could be cultivated profitably and sustainably for commercial cultivation in the low land areas of the Afar regional state and other similar agro-ecology, and could also increase the income of smallholder farmers and agro-pastoralists.

Key words: Date Palm, Clusters, Fao, Fruits/Cluster, Barhee, Medjool, Bunches

INTRODUCTION

The date palm is the oldest cultivated fruit tree known to have a close relationship with the world's major religions (FAO, 2002). Date palms are essentially produced in the hot arid regions of South-West Asia and North Africa area. The most important producers of date palm fruit include Egypt, Iran, Saudi Arabia, Pakistan, Iraq, Algeria, UAE, Oman, Sudan, Libya, Tunisia, Morocco, Mauritania, and the USA (Al-Khayri, 2005). World production is about 8.17 million metric tons (FAOSTAT, 2017a). The date palm produces fruit (dates) that may be dry, semi-dry, or soft in texture. The fruit is composed of more than 65% sugar (candy-like) with several minerals including potassium, calcium, iron, chlorine, phosphorus and magnesium (FAO, 1999). The date palm can withstand relatively harsh climate and soil conditions that no other crop can.

The date palm is well known as a cultivated and/or wild-grown crop in the Afar, Dire Dawa, Somali, Gambella, and Benishangul Gumuz regions of Ethiopia. However, the Afar region is by far the most important one in date palm cultivation (FAO, 2008). A number of date trees are grown in the Afar region following the Awash River banks, where a high concentration is found in the lower Awash area. Residents of the Afar communities produce date palms as a major food and cash crop, exclusively depending on local cultivars. This helps them to settle and live permanently in one area rather than moving in search of grass and water (personal communication). Informal surveys conducted in the Afar region so far have shown that the productivity of the local cultivars is very low as compared to the standard cultivars known in the world. Some local date palm cultivars in Ethiopia yield 15 to 20 kg plant-1 annually (Aziz, 2008), with a selling price of

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15–16 Birr per kg (personal communication). This shows that the production of date in the country can save foreign exchange and could help the growers to generate income.

Date fruit demand is steadily increasing in international markets (FAO, 2002), and the same is true in domestic markets, as evidenced by the amount of fruit imported in recent years (FAO, 2002). In the local market, demand reaches its maximum price during the months of Ramadan, the major fasting season for Muslims. Currently, date fruit production in the country is limited and is not satisfying the demand. As a result, the country imports a substantial amount of date fruit from abroad. For example, Ethiopia imported 2011 Mt of date in 2013 (FAOSTATb, 2017). Regardless of the suitable climatic conditions for the profitable production of date palms in the country, the contribution of the crop to the national economy is almost nil. The attempts so far made by Werer Agricultural Research Center (WARC) include the collection of the available date palm cultivars from the Afar region and eastern parts of Ethiopia and the introduction of a few exotic date palm varieties. However, the attempt to introduce commercial exotic cultivars has been a futile exercise as it was found costly.

The Ethiopian people are becoming aware of the benefits of this blessed fruit, especially during fasting. As a result, they are exerting sensible pressure on researchers and policymakers to obtain improved technologies for extending their production to have sufficient date fruits for the growing local and international markets. Hence, WARC, with FAO (Food and Agricultural Organization) collaboration, introduced improved tissue-cultured date palm varieties from Israel and England. Therefore, research has been conducted on introduced improved varieties with the main objective of evaluating and registering the best performing variety with desirable yield and quality.

MATERIALS AND METHODS

Description of the Study Area

The experiment was conducted at Werer Agricultural Research Center at the horticultural experimental site and at Assayta and Afambo districts on agro-pastoral farms. The experimental locations were characterized by very long hot and dry seasons with erratic rainfall; on a rise overlooking a stretch of the Awash River, palms and cultivation.

The Werer Agricultural Research Center is located in the Afar National Regional State, Zone-3, Amibara district, Werer town, which is 280 km northeast of Addis Ababa. It is located at 9o 60’ N latitude and 40o 9’ E longitude with an altitude of 740 meters above sea level (m.a.s.l.). Light-textured alluvial and black soils with a pH of 8.4 are the dominant soil types of the experimental site (WARC, 2007). In the surface soil (0–30 cm), soil organic matter ranges from 0.46 to 2.08%. The cation exchange capacity (CEC) also varies from 15–50 mg/100 g of soil. The exchangeable Na value is higher than both the Mg and K contents of the soil. The mean annual temperature is 34 ^{O}C, while the mean annual rainfall and evapotranspiration are 560 and 2600 mm, respectively.

The Assayta district the distance between the Assayta district and Ethiopia's capital city of Addis Ababa is roughly 660.9 kilometers. The activity took place in a single agro-pastoral field under the supervision of Afar Pastoral Agricultural and Development Beuro. The site has an altitude range of 400–420 m and is situated between latitude 11° 34' 0.00" North and longitude 41° 25' 60.00" East. Vertisols, sandy soils, and deposits of silt and fine sand particles that occur in the plain, flat areas where farming is performed are the predominant soil types in these regions. Assayta's climate is generally classified as dry, with some semi-arid agro-ecological zones where cattle rearing serves as the community's primary source of income. The area's temperature hovers around 32 ° c. on average, however from May to September, when it's hot, it can reach 42 ° c With an average annual rainfall of 200 to 250 mm, the rainfall is bimodal with an erratic distribution, with the long rainy season occurring between mid-June and mid-September, and the short rainy season occurring between March and April (Afar Pastoral Agricultural and Development Beuro, 2006).

The Afambo district Ethiopia's capital city, Addis Ababa, is roughly 675.3 km far from the Afambo district. A group of agro-pastoralists managed the research while it was conducted on the agro-pastoral field. The experimental area is located at an altitude of 342 meters above sea level, between latitude 11° 28' 37.3" North and longitude 41° 41' 02.5" East. Black, sandy, vertisols, and deposits of silt and fine sand particles that follow in the plain, flat areas where farming is performed are the major soil types in these areas (Afar Pastoral Agricultural and Development Beuro, 2006). In terms of climate, Afambo is an arid agroecological region where cattle farming provide the majority of the community's income. The region's typical annual rainfall ranges from 110 to 200 millimeters, with the long rainy season running from mid-June to mid-September and the short rainy season lasting from March to April. The average temperature in the area is around 38℃ (Afar Pastoral Agricultural and Development Beuro, 2006).

Field Experiment

In 2009, WARC and FAO introduced fourteen (14) tissue-cultured commercialized date palm varieties from England and Israel. The recently introduced materials were established in the Afar region at three different locations WARC, Assiyta, and Afambo. Out of the 12 varieties, two (Barhee and Medjool) were early fruiting types and each was assessed separately. Ten meters were left between plant rows and the trees when they planted. The field's soil type was verti soil, and other agronomic management techniques were uniformly applied. The field was irrigated with furrow irrigation at intervals of fifteen days. The Werer Research Center evaluated the varieties' cumulative fruit yields over two successive cropping seasons in addition their vegetative performance in Afambo and Assayta. Following harvest, the quantity of fruits per cluster and bunch as well as the weight of fruits per bunch were determined in the lab.

Statistical Analysis

Using SAS software, version 9.0, the independent two-sample t-test and correlation analysis were carried out (SAS Institute Inc., 2002). In order to determine whether there was a statistically significant difference between the two varieties at the 95% confidence level, the averages of two samples were compared.

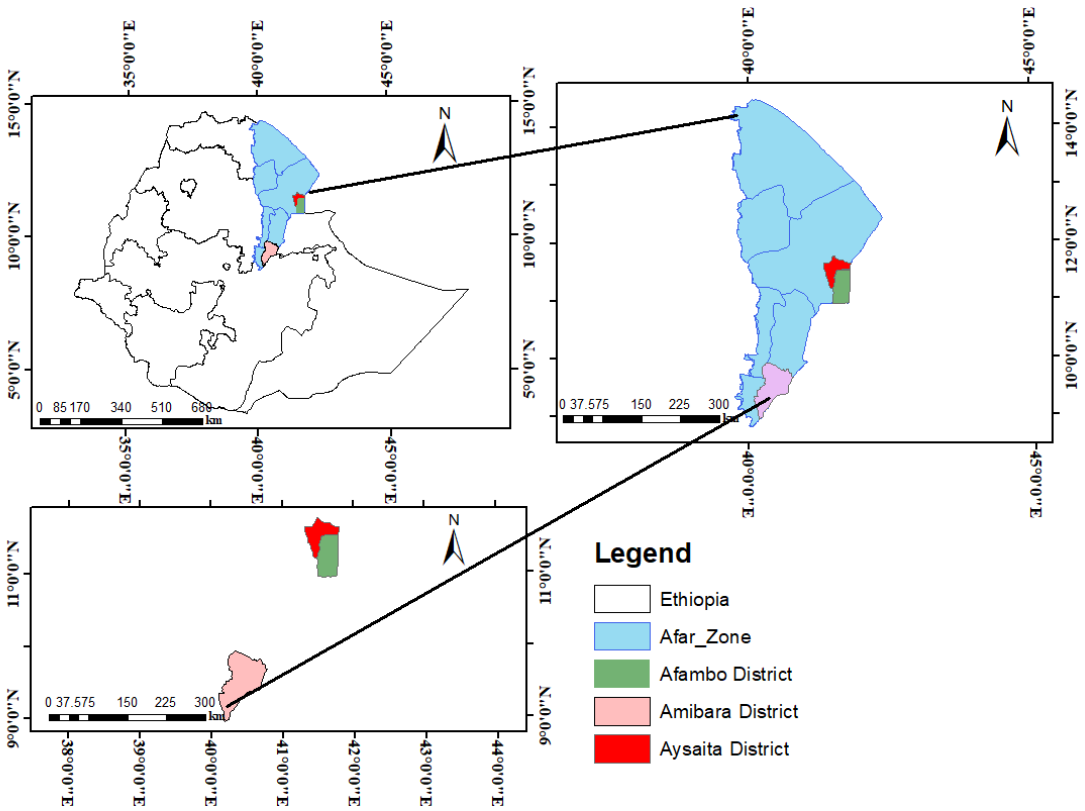

Fig. 1: Location map of the study area.

RESULTS and DISCUSSION

Yield performance of registered varieties Barhee and Medjool

The performance of the average fruit yield and yield-related traits of the Barhee variety was compared to the performance of the Medjool variety based on the sample size of each variety being N=26 (Table 1). An independent samples T-test for average number of bunches per plant, clusters per bunch and date fruits per cluster revealed that the Barhee variety had a significantly higher average number of bunches per plant (M=18.42, SD=7.03) than the variety Medjool (M=13.77, SD=2.64), (t (31.90)=3.16, P<0.0001). Similarly, variety Barhee had a significantly higher average number of clusters per bunch (M=1680.58, SD=706.83) than variety Medjool (M=704.19, SD=2.64), (t (35.20)=6.40, P<0.0001).

Contrarily, variety Barhee had a significantly lower average number of date fruits per cluster (M=8.81, SD=3.47) than variety Medjool (M=12.33, SD=7.75), (t (34.60)=-2.11, P<0 .04). An independent samples T-test for average fruit yield per plant, bunch and cluster revealed that the Barhee variety had a significantly higher average fruit yield per plant (M=68.39, SD=13.52) than the variety Medjool (M=50.87, SD=9.23), (t (26.80)=2.83, P<0.01). Similarly, variety Barhee had a significantly higher average date fruit yield per bunch (M=7.66, SD=4.75) than variety Medjool (M=5.16, SD=1.59), (t (30.50)=2.54, P<0.02). Inversely, variety Barhee had a significantly lower average fruit yield per cluster (M=107.74, SD=42.61) than variety Medjool (M=298.54, SD=207.63), (t (27.10)=-4.59, P<0.0001).

In general, variety Barhee had an advantage in average fruit yield per bunch and plant over variety Medjool by 976.36 and 17.52 kg, respectively. Inversely, variety Medjool had an advantage in average fruit number and yield per cluster over variety Barhee by 3.52 and 190.80 g, respectively. This indicates that the Medjool variety fruits per cluster are thicker and denser than Barhee, due to genetic variation existing among them. It was also reported by Omar and El-Abd (2014) that genetic makeup finally affects fruit holding after fertilization, in addition to pollen viability and germination percentage. However, the yield of the Medjool variety was inferior due to the fact that Barhee had a high number of bunches per plant and clusters per bunch of 4.65 and 976.39, respectively.

Yield performance of variety Barhee in 2013/14 and 2014/15 cropping season

The performance of the Barhee variety in 2013/14 was compared to the performance of the 2014/15 cropping season based on a sample size of N=29 and N=26, respectively (Table 2). An independent samples T-test for average number of bunches per plant, clusters per bunch, and fruits per cluster revealed that the Barhee variety produced significantly more bunches per plant (M=18.42, SD=7.03) and clusters per bunch (M=1680.58, SD=706.83) in 2014/15 than in the previous cropping season (M=3.83, SD=3.49), (t (35.70)=-9.59, P<0.0001) and (M=64.20, SD=17.79), (t (25.00)=-11.66, P<0.0001), respectively.

Similarly, the Barhee variety produced significantly more average fruit yield per plant in 2014/15 (M=158.79, SD=153.52) than in 2013/14 (M=32.57, SD=32.17), (t (27.00)=-4.11, P<0.0003). In contrast, the average fruit number and yield per cluster were significantly higher in the 2013/14 cropping season (M=16.68, SD=3.80) and

Table 1: Average fruit yield and yield related traits of Barhee and Medjool date palm varieties average over 26 samples at WARC in 2013/14 and 2014/15 cropping seasons

Variety	Statics	Parameters					
		ANBPP	ANCPB	ANFPC	AFYPP	AFYPB	AFYPC
Barhee	Mean	18.42 a	1680.58 a	8.81 b	68.39 a	7.66 a	107.74 b
	Minimum	11.00	1064.00	3.60	29.40	2.10	41.30
	Maximum	41.00	4634.00	15.00	705.20	18.00	200.70
	STD	7.03	706.83	3.47	13.52	4.75	42.61
	SE	1.38	138.62	0.68	30.11	0.93	8.36
Medjool	Mean	13.77 b	704.19 b	12.33 a	50.87 b	5.16 b	298.54 a
	Minimum	10.00	138.00	5.00	22.40	1.60	56.00
	Maximum	18.00	1305.00	34.00	126.00	8.30	661.00
	STD	2.64	326.30	7.75	9.23	1.59	207.63
	SE	0.52	63.99	1.52	5.73	0.31	40.72
Diff (1-2)	Mean	4.65 **	976.39 **	-3.52 *	17.52 **	2.50 *	-190.80 **
	STD	5.31	550.49	6.01	110.51	3.54	149.87
	SE	1.47	152.68	1.67	30.65	0.98	41.57
Method		UNEQ	UNEQ	UNEQ	UNEQ	UNEQ	UNEQ
DF		31.90	35.20	34.60	26.80	30.50	27.10
t Value		3.16	6.40	-2.11	2.83	2.54	-4.59
P-Value		0.0001	<.0001	0.04	0.01	0.02	<.0001

Means followed by different letter within the same column are significantly different at 95% confidence interval, ANBPP=average number of bunch plant $^{-1}$, ANCPB=average number of cluster bunch $^{-1}$, ANFPC=average number of fruit cluster $^{-1}$, AFYPP=average fruit yield plant $^{-1}$(kg plant $^{-1}$), AFYPB=average fruit yield bunch $^{-1}$ (kg bunch $^{-1}$) and AFYPC=average fruit yield cluster $^{-1}$(g cluster $^{-1}$)

Table 2: Average fruit yield and yield related traits of Barhee variety in 2013/14 and 2014/15 cropping season at WARC

Year	Statics	Parameters					
		ANBPP	ANCPB	ANFPC	AFYPP	AFYPB	AFYPC
2013/14	Mean	3.83 b	64.20 b	16.68 a	32.57 b	8.28	148.54 a
	Minimum	1.00	28.00	9.00	3.00	3.00	77.07
	Maximum	12.00	120.00	25.00	132.00	18.00	206.00
	STD	3.49	17.79	3.80	32.17	2.90	32.44
	SE	0.65	3.30	0.71	5.97	0.54	6.02
2014/15	Mean	18.42 a	1680.58 a	8.81 b	158.79 a	7.66	107.74 b
	Minimum	11.00	1064.00	3.60	29.40	2.10	41.30
	Maximum	41.00	4634.00	15.00	705.20	18.00	200.70
	STD	7.03	706.83	3.47	153.52	4.75	42.61
	SE	1.38	138.62	0.68	30.11	0.93	8.36
Diff (1-2)	Mean	-14.60 **	-1616.00 **	7.87 **	-126.20 **	0.63	40.80 **
	STD	5.45	485.63	3.65	108.00	3.88	37.58
	SE	1.47	131.16	0.99	29.17	1.05	10.15
Method		UNEQ	UNEQ	E-VAR	UNEQ		E-VAR
DF		35.70	25.00	53.00	27.00	40.50	53.00
t Value		-9.59	-11.66	7.99	-4.11		4.02
P-Value		<.0001	<.0001	<.0001	0.0003	NS	0.0002

Means followed by different letter within the same column are significantly different at 95% confidence interval, ANBPP=average number of bunch plant $^{-1}$, ANCPB=average number of cluster bunch $^{-1}$, ANFPC=average number of fruit cluster $^{-1}$, AFYPP=average fruit yield plant $^{-1}$(kg plant $^{-1}$), AFYPB=average fruit yield bunch $^{-1}$ (kg bunch $^{-1}$) and AFYPC=average fruit yield cluster $^{-1}$(g cluster $^{-1}$)

(M=148.54, SD=32.44) than in the 2014/15 cropping season (t (53.00)=7.99, P<0.0001 and (t (53.00)=4.02, p=0.0002), respectively). Both test methods indicated that there was a lack of evidence for a significant difference in variety Barhee between the two cropping seasons for average fruit yield per bunch (t (53)= 0.60 and p=0.5533 for the pooled test and t (40.5)=0.58 and p=0.5640 for the Satterthwaite test).

Generally, Barhee had a higher average number of bunches per plant (18.42), an average number of clusters per bunch (1680.58), and an average fruit yield per plant (158.79 kg) in 2014/15 than in the 2013/14 cropping season. This might be due to the increment in the age of the tree; an increase in bunches to certain limits of age will increase yield and yield components. A study by Baloch *et al.* (2014) under different categories by farm size and the age of the tree in Pakistan indicated that an increase in age increases fruit yield in date palm, where a higher yield per tree was observed in the range of 10–20 years of age. Inversely, Barhee had a lower average number of fruits per cluster (8.81) and an average fruit yield per cluster (107.74 g) in 2014/15 than in the 2013/14 cropping season. This demonstrated that when a bunch's weight climbed over the date palm tree, the fruit-filling capacity of the tree declined. The average fruit per cluster decreased as a consequence of some fruit being aborted from the cluster. The increase in crop load led to a lower mean fruit weight and a higher proportion of smaller fruit, as according results from many authors (Forshey and Elfving, 1977; Palmer et al., 1997; Wünsche et al., 2000, 2005; Wright et al., 2006; Embree et al., 2007).

In the situation of Barhee, which was examined over a two-year period, it was observed that while the average number of bunches per plant and the average number of clusters per bunch increased over succeeding years, the average fruit yield per plant actually declined. This is in

Table 3: Average fruit yield and yield related traits of Medjool variety in 2013/14 and 2014/15 cropping season at WARC

Year	Statics	Parameters					
		ANBPP	ANCPB	ANFPC	AFYPP	AFYPB	AFYPC
2013/14	Mean	7.76 b	81.02 b	9.05	88.17	25.44	104.86 b
	Minimum	1.00	24.25	1.60	2.00	1.00	26.90
	Maximum	25.00	189.33	32.00	502.00	502.00	272.10
	STD	5.40	38.81	6.26	106.14	91.80	55.86
	SE	1.00	7.21	1.16	19.71	17.05	10.37
2014/15	Mean	13.77 a	704.19 a	12.33	72.16	5.16	298.54 a
	Minimum	10.00	138.00	5.00	22.40	1.60	56.00
	Maximum	18.00	1305.00	34.00	126.00	8.30	661.00
	STD	13.77	326.30	7.75	29.23	1.59	207.63
	SE	0.52	63.99	1.52	5.73	0.31	40.72
Diff (1-2)	Mean	-6.01 **	-623.20 **	-3.28	16.02	20.27	-193.70 **
	STD	4.33	225.87	7.00	79.72	66.73	148.27
	SE	1.17	61.00	1.89	21.53	18.02	40.04
Method		UNEQ	UNEQ	E-VAR	UNEQ	UNEQ	UNEQ
DF		41.60	25.60	53.00	32.70	28.00	28.20
t Value		-5.32	-9.68	0.74	0.78	1.19	-4.61
P-Value		<.0001	<.0001	0.09	0.44	0.24	<.0001

Means followed by different letter within the same column are significantly different at 95% confidence interval, ANBPP=average number of bunch plant $^{-1}$, ANCPB=average number of cluster bunch $^{-1}$, ANFPC=average number of fruit cluster $^{-1}$, AFYPP=average fruit yield plant $^{-1}$(kg plant $^{-1}$), AFYPB=average fruit yield bunch $^{-1}$ (kg bunch $^{-1}$) and AFYPC=average fruit yield cluster $^{-1}$(g cluster $^{-1}$)

Table 4: Fruit quality traits of Barhee and Medjool date palm varieties average over 30 sample at WARC in 2013/14 and 2014/15 cropping seasons

Variety	Statics	Parameters								
		DL	DWI	DWE	SL	SWI	SWE	PT	PWE	TSS
Barhee	N	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Minimum	2.55	0.85	2.10	0.90	0.30	0.60	0.20	1.20	46.00
	Maximum	3.00	1.35	4.20	2.05	0.70	1.20	3.15	3.20	49.00
	Mean	2.80 b	1.12 a	2.95 a	1.74	0.43	0.81	0.65 a	2.11 a	47.78
	STD	0.13	0.14	0.55	0.23	0.10	0.13	0.57	0.53	0.98
	LCL Mean	2.75	1.07	2.75	1.65	0.39	0.76	0.44	1.91	47.42
	UCL Mean	2.84	1.17	3.16	1.82	0.46	0.86	0.86	2.30	48.15
	SE	0.02	0.02	0.10	0.04	0.02	0.02	0.10	0.10	0.18
Medjool	N	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Minimum	2.67	0.88	2.22	1.38	0.35	0.60	0.35	1.35	45.00
	Maximum	3.07	1.20	3.20	2.02	0.63	0.95	0.60	2.45	49.00
	Mean	2.89 a	1.02 b	2.67 b	1.78	0.46	0.79	0.44 b	1.86 b	47.33
	STD	0.11	0.07	0.24	0.13	0.06	0.08	0.07	0.24	1.06
	LCL Mean	2.85	1.00	2.58	1.73	0.44	0.76	0.41	1.77	46.94
	UCL Mean	2.93	1.05	2.77	1.83	0.48	0.82	0.46	1.95	47.73
	SE	0.02	0.01	0.04	0.02	0.01	0.02	0.01	0.04	0.19
Diff (1-2)	Mean	-0.09**	0.10**	0.28*	-0.05	-0.04	0.02	0.21*	0.24*	0.45
	STD	0.12	0.11	0.43	0.19	0.08	0.11	0.41	0.42	1.02
	SE	0.03	0.03	0.11	0.05	0.02	0.03	0.10	0.11	0.26
Method		E-VAR	UN-EQ	UN-EQ	UN-EQ	UN-EQ	UN-EQ	UN-EQ	UN-EQ	E-VAR
DF		58.00	43.90	39.90	46.90	49.70	49.00	29.80	40.60	58.00
t-value		-3.03	3.48	2.54	-0.96	-1.64	0.75	2.01	2.26	1.71
P-Value		0.00	0.00	0.02	0.34	0.11	0.46	0.05	0.03	0.09

Means followed by different letter within the same column are significantly different at 95% confidence interval, DL= date length (mm), DWI= date width (mm), DWE= date weight (g), SL= seed length (mm), SWI= seed width (mm), SWE= seed weight (g), PT= pulp thickness (mm), PWE= pulp weight (g) and TSS= total soluble solid (^{o}Brix)

Table 5: Comparison of vegetative characters of registered varieties of date palm (2013/15)

Variety	Harvest period		Fruit type	Fruit color
	Start	End		
Barhee	July	August	*Soft*	Yellow
Medjool	June	July	*Soft*	Yellow

line with a study by Philippe et al. (2005) that showed that when the number of fruits on a plant rose, the average growth rate of each fruit decreased. The length and circumference of the harvested fruits decreased with a rise in fruit number, while the ratio of length to circumference decreased (Marcelis, 1994).

Yield performance of variety Medjool in 2013/14 and 2014/15 cropping season

The performance of the variety Medjool in 2013/14 was compared to the performance of the 2014/15 cropping season based on a sample size of N=29 and N=26, respectively (Table 3). An independent samples T-test for average number of bunches per plant and clusters per bunch revealed that the variety Medjool had significantly higher average number of bunches per plant (M=13.77, SD=13.77), average number of clusters per bunch (M=704.19, SD=326.30) and average fruit yield per cluster (M=298.54, SD=207.63) in 2014/15 than in 2013/14 (M=7.76, SD=5.40), (t (41.60) =-5.32, P<0.0001),

(M=81.02, SD=38.81), (t (25.60) =-9.68, P<0.0001) and (M=104.86, SD=55.86), (t (28.20) =-4.61, P<0.0001), respectively.

Both test methods indicated that there was a lack of evidence for a significant difference in variety Medjool between the two cropping seasons for average number of fruits per cluster (t (53)= -1.73 and p=0.0889 for the pooled test and t (48.1) =-1.71 and p=0.0932 for the Satterthwaite test) and average fruit yield per plant (t (53)= 0.74 and p=0.4602 for the pooled test and t (32.7)=0.78 and p=0.4408 for the Satterthwaite test) and average fruit yield per bunch (t (53)= 1.12 and p=0.2657 for the pooled test and t (28)=1.19 and p=0.2444 for the Satterthwaite test).The average number of bunches per plant (13.77), the
average number of clusters per bunch (704.19), and average fruit yield per cluster (298.54 kg) of Medjool were higher in 2014/15 than in the 2013/14 cropping season. This showed a similar trend as the Barhee variety performed, where increases in yield and yield components showed an increase in a year. However, as compared with the Barhee variety, which showed an increment in yield from 32.57 kg/tree to 158.79 kg/tree in the respective years of 2013/14 to 2014/15, the Medjool variety showed insignificant differences over years. This indicates that the Medjool variety is less sensitive to alternate bearing than the Barhee even though they receive similar agronomic management. In line with the current findings, Jonkers, H. (1979) and Batjar, L.P., and Westwood, M.N. (1958) reported that alternate bearing is exaggerated by several factors, including genetic factors, abiotic and biotic influences, and poor culture methods during the "on" year.

Quality traits of the two registered varieties Barhee and Medjool

The performance of the fruit quality traits of the Barhee variety was compared to that of the Medjool variety using a sample size of N=30 for each variety (Table 4). An independent samples T-test for date width, weight, pulp thickness, and seed weight revealed that Barhee had significantly higher date width (M=2.80, SD=0.14) than variety Medjool (M=1.02, SD=0.07), (t (43.90)=3.48, p 0.001), date weight (M=2.95, SD=0.55) than variety Medjool (M=2.67, SD=0.07), (t (29.80)=2.01, p =0.05) and pulp weight (M=2.11, SD=0.53) than variety Medjool (M=1.86, SD=0.24), (t (40.60)=2.26, P<0.03). Barhee, on the other hand, had a significantly shorter average date length (M=2.80, SD=0.13) than Medjool (M=2.89, SD=0.11), (t (58.00) =-3.03, p 0.001).

Overall, compared to the variety Medjool, Barhee had increased date width, date weight, pulp thickness, and weight by 9.8%, 10.49%, 47.73%, and 13.44%, respectively. In contrast, Medjool had an average date length that was 38.94% longer than Variety Barhee's. Similar to this, Zaid et al. (2002) noted that dates vary widely in terms of length (18 to 110 mm), weight (2-60 g), color (yellow to black), taste, and seed (also known as the pit, stone, or kernel), which is hard-coated, rectangular, and weighs 0.5 to 4 grams.

Vegetative performance of Barhee and Medjool varieties

Mean values of morphological characters of the two evaluated varieties are shown in Figure 2. The data shows large variability between the two evaluated varieties (Barhee and Medjool) and over the two production years. These types of vegetative tools (morphology) are so important in the genotype development process and are critical in date palm cultivar selection and adaptation (Hamza *et al.* 2009, Barrow, 1998, IPGRI, 2005). The vegetative stage of any plant realizes the development of additional leaves while encouraging a gradual but clear increase in the plant's height. Accordingly, variety Berhee showed an increment in plant height, canopy spread and leaf number of 14.95%, 18.67%, and 7.11%, respectively, over the two successive cropping years.

Similarly, the variety Medjool showed an increment in plant height, canopy spread, and leaf number of 16.13%, 14.29%, and 6.75%, respectively, over the two successive cropping years. These vegetative characteristics can be used as a gauge to determine the differences between the various date palm kinds (Djerouni et al. 2015). This study agreed with Haider et al. (2015), who determined that the pinna number, length, width, and leaf palm length are characteristics that help to differentiate

Table 6: Pearsons' Correlation of yield with yield related traits

	ANCPB	ANFPC	AFYPP	AFYPB	AWFPC	DL	DWI	DWE	SL	SWI	SWE	PT	PWE	TSS
ANBPP	0.42**	-0.03	0.87**	0.59**	-0.10	0.02	0.47**	0.38**	-0.12	-0.07	0.11	0.29*	0.44**	0.24
ANCPB	1.00	-0.26	0.51**	0.54**	-0.44**	-0.23	0.23	0.20	-0.09	-0.25	-0.01	0.14	0.19	0.02
ANFPC		1.00	-0.08	-0.13	0.24	0.23	-0.26	-0.06	-0.08	0.04	-0.10	0.08	0.01	-0.06
AFYPP			1.00	0.86**	-0.16	0.10	0.39**	0.35**	0.04	-0.15	0.17	0.14	0.35**	0.25
AFYPB				1.00	-0.22	0.06	0.23	0.20	0.13	-0.10	0.24	0.10	0.18	0.21
AWFPC					1.00	0.25	-0.22	-0.08	-0.07	0.16	-0.04	-0.12	0.01	0.05
DL						1.00	0.15	0.29*	0.49**	0.03	0.17	0.03	0.12	0.02
DWI							1.00	0.68**	-0.03	0.09	-0.04	0.28	0.66**	0.14
DWE								1.00	0.19	-0.14	0.10	0.36**	0.88**	0.25
SL									1.00	-0.01	0.41**	-0.11	-0.18	-0.01
SWI										1.00	-0.01	-0.01	-0.07	-0.20
SWE											1.00	0.07	-0.18	0.16
PT												1.00	0.45**	0.09
PWE													1.00	0.21

*and **=indicate significant and highly significant difference at P<0.05 and 0.01, respectively, ANBPP=average number of bunch plant $^{-1}$, ANCPB=average number of cluster bunch $^{-1}$, ANFPC=average number of fruit cluster $^{-1}$, AFYPP=average fruit yield plant $^{-1}$, AFYPB=average fruit yield bunch $^{-1}$, AFYPC=average fruit yield cluster $^{-1}$, DL= date length (mm), DWI= date width (mm), DWE= date weight (g), SL= seed length (mm), SWI= seed width (mm), SWE= seed weight (g), PT= pulp thickness (mm), PWE= pulp weight (g) and TSS= total soluble solid (^{o}Brix).

among the types of date palm in their study on the sixteen Pakistani date palm varieties from various origins in terms of vegetative features. The vegetative traits including thorn length, length of thorn area, and leaf palm length are appropriate traits that demonstrate the similarities and variations among the female palms, according to Hamadi *et al.* (2009) in their study of various Tunisian date palm varieties.

Harvesting and time of fruit set in date palms are important factors in determining the commercial production of date fruits. Accordingly, there were two harvesting times in date palm varieties, based on early and late maturity. Variety Menjool (June to July) was harvested one month earlier than Berhee (July to August) and remained un-harvested for two years (Table 5). Early season production and a longer harvesting period are crucial for obtaining the greatest market pricing, particularly when dates are in short supply. Zaid and Arias-Jimenez (2002) and Muralidharan *et al*. (2008) have published findings that are consistent with the available evidence.

Additional characterizations were also detected based on qualitative criteria such as fruit type and color. Both varieties' topicalities were also detected based on qualitative criteria such as fruit type and color. Both varieties showed a soft fruiting type and a yellow fruit color. The present investigation confirmed that there are variances in the physical properties of the fruits, in contrast to Mohamed Lemine *et al*., 2014, which examined 28 Mauritanian date palm varieties.

Correlation of yield and yield related traits

Table 5 shows the results of a simple correlation among average fruit yield per plant, average fruit yield per bunch, date width, date weight, and pulp weight in date palm varieties. The average fruit yield per plant (r=0.36**), date width (r=0.39**), date weight (r=35**), and pulp weight (r=0.35**) were all positively and significantly correlated. The current study was supported by the findings of Bashir *et al*., (2014) who observed that the fruit weight was positively correlated with the fruit dimension (length x diameter).

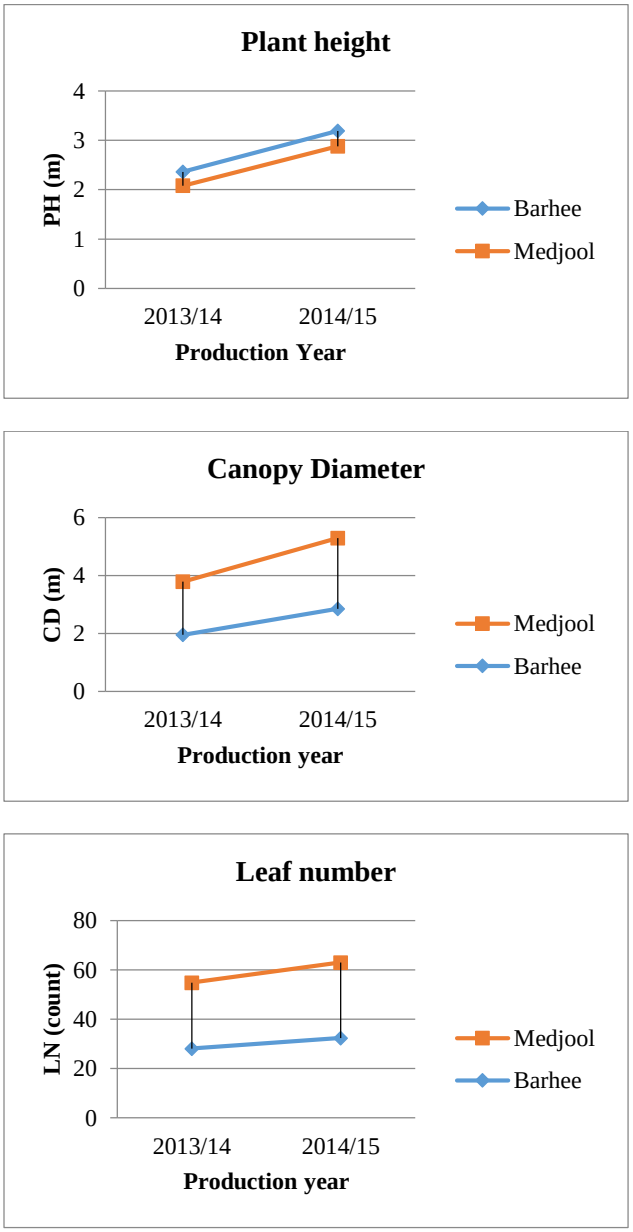

Fig. 2: Vegetative performance of the registered variety (Barhee and Medjool) over two successive production years.

The average number of clusters per bunch was significantly and adversely linked with the average weight of fruit per cluster. This demonstrates that when the number of clusters per bunch rises, the photoassimilation translocation among the fruits per cluster may be constrained, resulting in a drop in the weight of the average fruit per cluster. Bashir et al. (2014) found that for all levels of strand thinning of fruit, the fruit weight was inversely connected with the quantity of fruits produced per plant.

Variety maintenance and dissemination

WARC's horticultural field is home to trees and offshoots of the Barhee and Medjool varieties. Planting material multiplication of the varieties is underway through their off-shoot multiplication. The propagation is still done in the traditional way by offshoots, which are produced in the leaf axils and usually appear at or under the ground level surrounding the stem base However, the old-style method of vegetative propagation through offshoot has its own restrictions. Offshoots are produced in an inadequate quantity for a certain age in the lifetime of a young palm tree. Offshoots depend on the genetic makeup of the cultivar and environmental factors. The amount of offshoots produced by a single date palm tree is highly variable and varies from one cultivar to another. It is slow in survival, laborious, time-consuming, and expensive. Transmission of disease-causing pathogens and insects is factor discouraging offshoot propagation. Therefore, modern propagation methods of date palms through tissue culture should be started in the country, especially for potential local genotypes that have limited offshoot numbers and registered varieties to disseminate among end users.

Summary and Conclusions

The findings of this study demonstrated that, in terms of average fruit weight and offshoot production capacity,

the registered varieties Barhee and Medjool are superior to the other date palm types. Additionally, study revealed that when compared to other date palm varieties, the Barhee and Medjool varieties have better fruit weight per bunch and average pulp weight. In conclusion, while the ministry of agriculture plays a significant role in multiplying planting materials by tissue culture, the newly registered varieties Barhee and Medjool could be grown profitably and sustainably for commercial cultivation in the low land areas of the Afar regional state and other similar agro-ecologies. This could also increase the income of smallholder farmers and agro-pastoralists.

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