Current Trends in Natural Sciences
Vol. 11, Issue 21, pp. 390-398, 2022
https://doi.org/10.47068/ctns.2022.v11i21.043

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

CROP PERFORMANCES AND GENETIC VARIABILITY ANALYSIS OF SEVEN TOMATO GENOTYPES CONDUCTED UNDER AGRO ECOLOGICAL FARMING MANAGEMENT

Abdelmadjid Boulgheb [1]*, Zeineb Baaziz [1], Amina Falfali [1], Lies Reguieg [2], Abd El Kader Aissat [3]

[1] Natural Resources Laboratory, Adrar Uuniversity, Algeria
[2] Ecole Nationale Supérieure Agronomique (ENSA) EL Harrach, Algeria
[3] Department of Nature Sciences and Life, Blida University, Algeria

Current Trends in Natural Sciences

Abstract
Tomato crop occupies a predominant place after that of potatoes in market garden crops in Algeria. The main purposes of this study were to evaluate crop performances, variability of some morphologic and phenologic traits, and correlations with the yield of seven (07) genotypes of tomato. The trials were carried out on Random Complete Blocs Design (RCBD) with three replications at the local unheated greenhouse during the period from November to June 2018. The most important morphological markers used were stem growth rate, inflorescence (Number of flowers, length of peduncle) and fruit characters (length and circumstance), phenologic stages, and average yield. The effect of the genetic material on the observed variability was significant for all the traits considered. Additionally, we noticed positive values of correlation coefficients of yield with stem length between every two clusters and the number of leave under cluster, average fruit weight, and earliness to flowering. Additionally, earliness to flowering shows very high and stable correlations (above 0.8) with yield during the crop cycle. The principal component analysis showed that the first two components generated 62.17 % of variability, while the first four components accumulated more than 93 % (93.51 %) of the total diversity. Moreover, the dendrogram analysis classified the genotypes within 03 groups.

Keywords: Cluster analysis, Genetic diversity, Principal analysis components Tomato, Variability

1. INTRODUCTION

With an average production of 11 million quintals (MADR, 2009) for all uses combined (vegetable and processing) on an annual area of about 33 000 ha (Food and Agriculture Organization (FAO, 2010), in Algeria, tomato crop occupies a predominant place after that of potatoes in market garden crops. The use of special varieties for processing tomatoes, including tomato juice, sauce, puree, paste, and dried tomato, are more than for fresh consumption and of about 19830 ha (MADR,2017). According to Osei et al., (2014), on the planetary level, tomato crop production occupies about 14% of the world's vegetable production. Tomatoes have significantly high nutritional value; in fact, it is an important source of vitamin C, vitamin A, and antioxidants (Beecher, 1998; Raffo et al., 2002).

Historically, Foolad, (2007) reported that work for the genetic improvement of new varieties began early in Europe (around the beginning of the nineteenth century). The main purposes of tomato

*Corresponding author, E-mail address: madjidboulgheb@gmail.com

Current Trends in Natural Sciences
Vol. 11, Issue 21, pp. 390-398, 2022
https://doi.org/10.47068/ctns.2022.v11i21.043
Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521
Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

breeding programs are to discover and utilize important genes (Bai and Lindhout, 2007), to create new varieties with the increasingly high yield (Poczai et al., 2011). For Foolad (2007), disease resistance, earliness to maturity besides some fruit quality characteristics are among desired traits. That mostly involves a better knowledge and a good later handling of tomato genetic resources diversity. According to Mwirigi et al., (2009) the determination of polymorphism among accessions is of a paramount importance for the use of plant genetic resources. Meanwhile, Reddy et al., (2013b) extend the list to other scientific fields such as taxonomy and classification of species. Researchers have a range of methods for evaluating plant genetic resources, including morphological markers that nowadays are widely used in plant breeding work (Henareh et al., 2015) and also for cultivar identification (Osei et al., 2014). Determination of genetic variation in tomatoes using morphological traits has been worldwide reported by many researchers (Agong et al., 2001; Mazzucato et al., 2008; Al Aysh et al., 2012; Osei et al., 2014; Herison et al., 2018). Indeed, the tomato clad is an interesting example for research on plant biodiversity, notably, on evolution, adaptation, human domestication, and nutrition perspectives (Peralta and Spooner 2007).
In Algeria, the practice of the tomato crop is very ancient and goes back to the beginning of the twentieth century, of which it is introduced in the Oran region in 1905. Then, it was spread gradually through the littoral region towards the center and the east of the country (Latigui, 1984). This long history of the crop in the region could explain the high diversity of shapes, sizes and colors remarked particularly in traditional markets, as well as a variety of culinary uses. Although the diversity of tomatoes can be identified by both morphological and molecular traits, Mekhlouf et al., 2006 reported that morphological ones showed significant differences between seasons and genotypes, indicating a differential genotypic variability and crop growth conditions.

2. MATERIALS AND METHODS

The trial experiment is conducted at an unheated greenhouse of Adrar University in the southwest desert region of Algeria, of which the geographic references are as follows: Latitude: 27°, 49' Longitude: 00° 18' Altitude: 278° 48'. The region is characterized by an extremely dry desert continental climate. According to the local Station of Meteorological National Agency, the annual average temperature is around 24 °C with seasonal fluctuations which pass from 12 °C, during winter season especially in December and January to more than 46 °C during July (Table 1).

Table 1. Temperature references (minimal, maximal and mean) in 2018

	Jan.	Feb.	Marsh	April	Mai	June	July	Aoug.	Sept.	Oct.	Nov.	Dec.	Mean
Min	4.96	6.07	13.21	16.52	23.88	27.66	30.55	30.36	22.78	22.16	11.377	5.59	17.93
Max	21.44	23.21	28.81	33.73	39.88	43.54	46.51	42.26	43.86	37.99	26.897	21.59	34.14
Mean	13.20	14.64	21.01	25.13	31.88	35.60	38.53	36.81	33.32	30.08	19.14	13.59	26.08

Table 2. Sunlight duration in 2018

	Jan,	Feb,	Marsh	April	Mai	June	July	Aoug	Sept,	Oct,	Nov,	Dec	Mean
Min	1.00	0.00	0.00	0.00	0.40	0.00	0.60	0.00	0.30	0.20	0.00	5.00	0.80
Max	9.35	9.50	11.00	11.50	12.20	12.20	12.45	12.10	11.75	10.65	9.55	9.56	10.61
Mean	7.87	7.43	8.41	8.41	7.20	8.75	13.40	13.20	11.45	10.65	8.1261	8.76	8.12

Source: Local station of Meteorological National Agency (MNA).

The trials were carried out during the period from November to June 2018 under unheated greenhouse. The major purpose of the experiment is to study the morphological characteristics of

*Corresponding author, E-mail address: madjidboulgheb@gmail.com

Current Trends in Natural Sciences
Vol. 11, Issue 21, pp. 390-398, 2022
https://doi.org/10.47068/ctns.2022.v11i21.043
Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521
Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

seven (07) most locally cultivated cultivars (Table 3). Regarding the texture of the soil, it is sandy clay whereas its pH is 7.01. The seeds were germinated on soaked paper tissues for 3 days and then sown on cell trays containing mixed media of compost with lime (10 %), a mixture of different sizes of sand (85 %), and cinders of tomato residue (5 %). After four weeks from sowing, the seedlings were then transplanted onto field beds. In each replication, each genotype was grown in a single row plot of 7.5 m length at spacing of 60 x 35 cm in three replications including 21 plants for each. Randomly Fifteen plants of each genotype and each replication were measured and subjected to systematic observations for their quantitative morphological traits and their means were undergone for statistical analysis.

Table 3. Codes of genotypes used during trials

Code	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Genotype	Sahara	Supermarmande	Tafna	Daylos	Chefa	Eva	Marmande

The most important morphological markers used to determine and select these genotypes were average length and diameter of fruit (cm), fruit weight (g), number of flowers and fruit per inflorescence, length of panicle (cm), height of the first inflorescence (cm), distance between every two inflorescences (cm), and number of leaves under each inflorescence, monthly growth rate (cm), earliness to flowering (day), the total weight of fruits picked up of each inflorescence (g), the number of lobes of each fruit and the average yield of each variety (qx/ha). Data were recorded on ten randomly selected plants from each genotype and each replication and their means were worked out for statistical analysis.

The mean values of data were subjected to both the normality test and the variance analysis as described by Steel and Torrie (1980). The least significant difference (LSD) according to Steel and Torrie (198**2**), correlation analysis to measure relation inter characters and PCA (principal component analysis) have been employed for morphological variation study and were performed using Matlab 2014 software. For grouping genotype, cluster analysis was achieved using the method of Ward based on squared Euclidean distance. Cluster analysis was performed using the statistic program Xlstat.

3. RESULTS AND DISCUSSIONS

Analysis of variance revealed a significant difference ($P \leq 0.01$) among genotypes for all the studied traits (Table 4). Mean values show a wide variation for all the considered characters and the percentage of the gap between the minimum value and the maximum performance for each studied trait is very high. For instance, in terms of the height of 1st cluster, the difference was 127.72 %, the distance of stem between 1st and 2nd cluster was 203.85 %, the length of the peduncle of 1st cluster was 347.62 %, for the earliness to the flowering of the 1st cluster was 59.22 %, the average number of fruit harvested per cluster was 60.67 % and yield per plant was 93.94 %.

The mean value of variation coefficient (CV %) for all the morphological characters studied is 10.42 %. Nevertheless, this mean value masks fluctuations among measured characters varying from lower values noticed, for the circumference of the fruit with a mean value of 3.68 % to relatively more elevated values observed especially for the number of harvested fruits per cluster with an average of 20.96 % (Table 4).

The study of correlation coefficient showed that in terms of earliness to flowering was globally and positively correlated with the stem length between all two successive clusters, the number of leaves between every two clusters, the fruits weight, circumstance and to relatively with their length, the

*Corresponding author, E-mail address: madjidboulgheb@gmail.com

Current Trends in Natural Sciences
Vol. 11, Issue 21, pp. 390-398, 2022
https://doi.org/10.47068/ctns.2022.v11i21.043

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

yield and to earliness to maturity. Furthermore, the correlations take progressively high remarkable values with the evolution and development of the crop cycle (Table 5).

Table 4. Performances, Principal Components Analysis, and analysis of variances of several traits of 07 varieties of tomato most cultivated in Adrar region (Southwest region of Algeria)

	Perform.		Principal Components analysis (PCA)			Correlations with			Other statistics Parameters	
Trait	Min	Max	**1**	**2**	**3**	Yield	Earl. to flow. 1st clust	Earl. to maturity 1st clast.	STDEVA	MCV
Stem Height from 1st to 2nd cluster	8,7	26,27	**0.182**	0.014	**0.234**	**0.88****	-0.054	-0.059	769.47**	8.17
Stem Height from 2nd to 3rd cluster	9,2	24,29	**0.248**	**0.401**	0.070	**0.83****	-0.196	-0.081	769.47**	7.03
Stem Height from 3rd to 4th cluster	8,4	24,66	**0.173**	**0.165**	0.009	**0.78***	-0.086	-0.057	541.19**	5.22
Stem Height from 4th to 5th cluster	9,1	25,08	0.009	0.078	0.135	**0.73***	-0.122	-0.102	863.38**	5.72
Plant height at 2nd month	62	116,6	**0.219**	**0.198**	**0.225**	**0.62**	-0.420	-0.054	986.19**	12.59
HPlant height at 3rd month	66	190,5	0.026	0.001	**0.184**	**0.80***	-0.187	-0.043	6215.49**	5.79
Plant height at 4th month	74	250,6	**0.156**	0.141	**0.149**	**0.79****	-0.075	0.051	39466.27**	6.13
Earliness to flowering to 1st cluster	30	44,82	0.137	**0.181**	0.078	0.14	1.000	**0.832***	617.69**	10.09
Earliness to flowering to 2nd cluster	44	59,22	**0.446**	0.120	0.054	0.42	**0.912****	**0.708***	731.28**	5.29
Earliness to flowering to 3rd cluster	55	68,97	0.096	0.097	0.089	**0.60**	**0.768***	0.656	522.28**	6.03
Earliness to flowering to 4th cluster	64	78,58	**0.184**	0.015	**0.294**	**0.60**	**0.665***	0.500	555.85**	3.86
Earliness to flowering to 5th cluster	73	88,75	**0.203**	0.124	0.089	**0.70***	0.530	0.366	537.83**	3.42
Height to 1st cluster	22	49,08	0.014	0.055	0.020	**0.60**	0.078	0.358	2288.07**	6.16
Length of 1st peduncle	1,3	5,97	**0.358**	0.081	**0.259**	0.38	0.053	0.431	61.18**	13.03
Length of 2nd peduncle	1,6	6,91	0.057	0.106	0.057	0.36	-0.004	0.417	63.96**	8.5
Length of 3rd peduncle	1,9	6,26	**0.203**	**0.210**	0.027	0.13	-0.107	0.318	63.96**	8.64
Flowers Number of 1st cluster	4,2	7,82	0.092	**0.281**	0.086	-0.10	-0.139	-0.068	29.33**	13.05
Flowers Number of 2nd cluster	5,3	8,06	0.018	**0.353**	**0.199**	-0.40	-0.028	-0.218	123.02**	14.78
Flowers Number of 3rd cluster	5,6	13,14	**0.162**	0.104	**0.158**	0.21	0.377	0.150	212.12**	16.18
Flowers Number of 4th cluster	5,4	15,88	0.001	0.080	0.006	0.251	0.291	-0.018	272.77**	14.93
Leaves number to 1st cluster	6,1	8,58	0.109	**0.246**	0.011	0.24	-0.389	-0.272	19.74**	5.23
Leaves number from 1st to 2nd cluster	6,1	8,58	**0.255**	0.082	**0.292**	0.24	-0.389	-0.272	21.98**	21.54
Leaves number from 2nd -3rd cluster	1,5	4,29	**0.233**	0.055	**0.213**	**0.61**	-0.008	-0.250	10.45**	11.45
Leaves number from 3rd -4th cluster	1,5	3,08	0.081	0.047	**0.162**	**0.62**	-0.103	-0.144	12.9**	5.1
Leaves number from 4th -5th cluster	1,3	3,23	0.113	0.008	0.014	**0.50**	-0.107	-0.212	13.98**	6.23
Fruits number picked up of 1st cluster	3,9	6,48	0.095	0.082	**0.514**	0.30	-0.096	0.167	166.39**	21.92
Fruits number picked up of 2nd cluster	3,8	6,38	**0.179**	0.053	**0.145**	0.37	-0.161	0.221	164.1**	20.17
Fruits number picked up of 3rd cluster	3,1	7,96	**0.373**	0.053	**0.176**	0.51	-0.265	0.151	187.47**	20.78
Fruits weight of 1st cluster	251	787,9	**0.186**	0.120	0.066	**0.91****	0.116	0.232	661020.9**	21.63
Fruits weight of 2nd cluster	253	828,7	**0.195**	0.007	**0.638**	**0.94****	0.209	0.108	717508.52**	20.95
Fruits weight of 3rd cluster	280	891	0.001	0.100	0.041	**0.98****	0.007	0.052	1120032.3**	18.1
Fruit mean weight of 1st cluster	40	123,1	**0.252**	**0.281**	0.075	**0.72***	0.204	0.176	17757.25	6.24
Fruit mean weight 2nd of cluster	40	156,9	0.013	0.015	0.140	**0.71***	0.309	0.041	23106.88	3.85
Fruit mean weight 3rd of cluster	44	151,2	**0.264**	**0.160**	0.060	**0.66***	0.230	-0.027	25515.36122	5.45
Number of fruit loges	2,3	9,09	0.044	0.027	0.064	0.25	0.028	-0.441	19.65**	9.53
Mean fruit circumstance of 1st cluster	13	21,91	0.031	0.035	**0.219**	**0.61**	0.216	0.034	32.06**	6.49
Mean fruit circumstance of 2nd cluster	13	24,77	0.029	0.058	0.042	**0.56**	0.523	0.145	19.55**	1.86
Mean fruit circumstance of 3rd cluster	13	23,25	**0.308**	0.108	0.131	**0.69***	0.152	-0.115	95.48**	2.72
Mean Fruit Length of 1st cluster	6,6	9,5	**0.171**	0.081	0.136	**0.59**	0.250	0.147	16.63**	5.22
Mean Fruit Length of 2nd cluster	6,8	10,54	0.001	**0.335**	0.009	0.34	0.140	-0.300	14.53**	8.24
Mean Fruit Length of 3rd cluster	7,2	10,2	**0.175**	**0.312**	**0.214**	**0.67***	0.355	0.086	40.38**	10.04
Production of 1st month	146	568,4	**0.454**	0.055	**0.220**	-0.10	-0.742	**-0.959****	405946.3**	19.7487
Production of 2nd month	476	1760	**0.200**	**0.311**	0.095	**0.95****	0.303	0.330	4291213.1**	17.477
Yield per plant	3089	7437	0.003	0.068	0.014	1.000	0.119	0.158	101928890.3**	7.02145
Earliness to maturity of 1st cluster	116	128,2	**0.147**	0.099	0.026	0.23	**0.832***	1.000	270.13**	1.91893
Earliness to maturity of 2nd cluster	125	133,6	0.141	0.107	0.141	0.37	**0.809***	**0.972****	139.91**	1.58983
Earliness to maturity of 3rd cluster	131	140,4	0.006	**0.290**	0.057	0.46	**0.715***	**0.924****	207.40**	2.39362
Mean maturation period of fruit	107	121,3	0.045	**0.166**	**0.237**	0.31	**0.906****	**0.938****	401.69**	2.56035

(*) $p < 0.05$ one tailed test. (**) $p < 0.01$ one tailed test.

*Corresponding author, E-mail address: madjidboulgheb@gmail.com

Current Trends in Natural Sciences
Vol. 11, Issue 21, pp. 390-398, 2022
https://doi.org/10.47068/ctns.2022.v11i21.043

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

Table 5: Matrix of Pearson correlation coefficients between studied traits

	Htb 1-2	Htb 2-3	Htb 3-4	Htb 4-5	H-pt-2m	H-pt-3m	H-pt-4m	Pr Fl 1Bq	Pr Fl 2Bq	Pr Fl 3Bq	Pr Fl 4Bq	Pr Fl 5Bq	H 1 b fl	Lg pd 1 bq	Lg pd 2bq	Lg pd 3bq	N Fl 1bq	N Fl 2bq	N Fl 3bq	N Fl 4bq	N-d-f 1b	Nb F. 1-2bq	Nb F. 2-3bq	Nb F. 3-4bq	Nb F.4-5bq	Nb Ft 1Bq	Nb Ft 2Bq	Nb Ft 3Bq	Pd Fts 1Bq	Pd Fts 2Bq	Pd Fts 3Bq	PdM Ft 1Bq	PdM Ft 2Bq	PdM Ft 3Bq	Nb loges	Circ,Ft 1Bq	Circ,Ft 2Bq	Circ,Ft 3Bq	Lg Ft 1Bq	Lg Ft 2Bq	Lg Ft 3Bq	Pds 1 m(g)	Pds 2 m(g)	Yield/pt	Pr.mat.Bq 1	Pr.mat.Bq 2	Pr.mat.Bq 3
Htb 2-3	**0.95	1																																													
Htb 3-4	**0.93	**0.97	1																																												
Htb 4-5	**0.90	**0.95	**0.99	1																																											
H-pt-2m	0.63	*0.80	*0.66	0.62	1																																										
H-pt-3m	**0.92	**0.99	**0.97	**0.96	*0.81	1																																									
H-pt-4m	**0.91	**0.98	**0.98	**0.97	*0.75	**0.99	1																																								
Pr Fl 1Bq	-0.05	-0.2	-0.09	-0.12	-0.42	-0.19	-0.07	1																																							
Pr Fl 2Bq	0.33	0.19	0.32	0.28	-0.19	0.19	0.3	**0.9	1																																						
Pr Fl 3Bq	0.54	0.46	0.56	0.52	0.12	0.47	0.57	*0.77	**0.95	1																																					
Pr Fl 4Bq	*0.66	0.56	*0.67	0.64	0.14	0.56	0.65	*0.67	**0.91	**0.98	1																																				
Pr Fl 5Bq	*0.74	*0.67	*0.78	*0.75	0.26	*0.67	*0.74	0.53	*0.82	**0.94	**0.98	1																																			
H 1 b fl	0.47	0.56	0.42	0.35	*0.80	0.56	0.54	0.08	0.18	0.42	0.34	0.4	1																																		
Lg pd 1 bq	0.07	0.15	-0.04	-0.12	0.59	0.15	0.1	0.05	-0.04	0.09	-0.05	-0.04	**0.8	1																																	
Lg pd 2bq	0.11	0.19	0	-0.08	0.64	0.2	0.15	0	-0.09	0.07	-0.07	-0.07	**0.84	**0.98	1																																
Lg pd 3bq	-0.09	0.02	-0.19	-0.25	0.56	0.03	-0.03	-0.11	-0.25	-0.13	-0.27	-0.27	*0.75	**0.94	**0.97	1																															
N Fl 1bq	-0.11	0.07	0.21	0.29	-0.07	0.14	0.19	-0.14	-0.06	-0.07	-0.01	0.01	-0.44	-0.47	-0.5	-0.5	1																														
N Fl 2bq	-0.2	-0.19	0	0.09	-0.53	-0.15	-0.08	-0.03	0.02	-0.1	-0.01	-0.04	*-0.82	**-0.91	**-0.87	*-0.82	*0.72	1																													
N Fl 3bq	0.28	0.12	0.28	0.32	-0.43	0.11	0.19	0.38	0.51	0.38	0.48	0.41	-0.55	*-0.66	-0.65	*-0.77	0.41	*0.67	1																												
N Fl 4bq	0.46	0.29	0.46	0.49	-0.32	0.28	0.35	0.29	0.52	0.46	0.59	0.55	-0.45	*-0.74	*-0.70	*-0.82	0.28	0.65	**0.93	1																											
N-d-f 1b	0.32	0.51	0.44	0.42	*0.74	0.53	0.47	-0.39	-0.21	0.05	0.06	0.22	*0.68	0.4	0.38	0.38	-0.1	-0.46	*-0.69	-0.47	1																										
Nb F. 1-2bq	0.32	0.51	0.44	0.42	*0.74	0.53	0.47	-0.39	-0.21	0.05	0.06	0.22	*0.68	0.4	0.38	0.38	-0.1	-0.46	*-0.7	-0.47	1	1																									
Nb F. 2-3bq	**0.86	*0.75	**0.83	**0.84	0.22	*0.72	*0.73	-0.01	0.38	0.49	*0.66	*0.73	0.01	-0.44	-0.41	-0.57	0.09	0.25	0.59	*0.79	0.09	0.09	1																								
Nb F. 3-4bq	**0.85	**0.88	**0.96	**0.98	0.48	**0.89	**0.91	-0.1	0.3	0.5	0.64	*0.73	0.17	-0.3	-0.26	-0.42	0.37	0.28	0.46	0.63	0.29	0.29	**0.89	1																							
Nb F.4-5bq	*0.79	*0.82	**0.91	**0.94	0.41	**0.83	**0.86	-0.11	0.29	0.48	0.63	*0.72	0.13	-0.39	-0.34	-0.47	0.32	0.33	0.41	0.64	0.35	0.35	**0.89	**0.98	1																						
Nb Ft 1Bq	0.23	0.44	0.51	0.55	0.39	0.51	0.55	-0.1	0.06	0.18	0.21	0.26	0.06	-0.04	-0.05	-0.14	*0.85	0.33	0.26	0.14	0.15	0.15	0.17	0.54	0.44	1																					
Nb Ft 2Bq	0.16	0.31	0.29	0.31	0.38	0.35	0.36	-0.16	-0.11	-0.03	-0.03	-0.02	0.07	0.22	0.2	0.12	0.64	0.09	0.21	-0.03	-0.08	-0.08	-0.04	0.26	0.08	*0.85	1																				
Nb Ft 3Bq	0.4	0.52	0.46	0.47	0.55	0.55	0.54	-0.26	-0.13	0.01	0.03	0.05	0.19	0.23	0.29	0.18	0.45	0.03	0.24	0.08	-0.06	-0.06	0.16	0.42	0.25	*0.74	**0.9	1																			
Pd Fts 1Bq	**0.91	**0.92	**0.87	*0.82	*0.76	**0.91	**0.91	0.12	0.43	*0.68	*0.72	*0.79	*0.76	0.39	0.42	0.22	-0.19	-0.44	0.04	0.19	0.48	0.48	0.62	*0.71	0.65	0.27	0.19	0.39	1																		
Pd Fts 2Bq	**0.91	*0.77	*0.77	*0.71	0.41	*0.72	*0.72	0.21	0.52	0.65	*0.73	*0.78	0.44	0.14	0.13	-0.1	-0.25	-0.33	0.35	0.46	0.14	0.14	*0.78	0.65	0.57	0.07	0.09	0.26	**0.85	1																	
Pd Fts 3Bq	**0.92	**0.84	*0.78	*0.73	0.62	*0.80	*0.77	0.01	0.31	0.49	0.57	0.64	0.54	0.31	0.3	0.09	-0.22	-0.43	0.2	0.28	0.24	0.24	*0.68	0.63	0.53	0.18	0.27	0.46	**0.88	**0.96	1																
PdM Ft 1Bq	*0.77	0.65	0.56	0.49	0.51	0.6	0.58	0.2	0.42	0.59	0.61	0.64	*0.72	0.4	0.45	0.3	*-0.67	-0.6	-0.08	0.13	0.35	0.35	0.52	0.39	0.39	-0.3	-0.3	-0.03	**0.83	*0.79	*0.76	1															
PdM Ft 2Bq	*0.78	0.56	0.56	0.51	0.18	0.49	0.5	0.31	0.56	0.63	*0.70	*0.73	0.35	0.02	0.02	-0.16	-0.52	-0.32	0.28	0.48	0.1	0.1	*0.74	0.48	0.48	-0.32	-0.35	-0.15	*0.69	**0.90	*0.77	**0.86	1														
PdM Ft 3Bq	*0.67	0.49	0.45	0.39	0.24	0.41	0.39	0.23	0.44	0.52	0.57	0.63	0.47	0.2	0.16	0.01	-0.63	-0.54	0	0.2	0.3	0.3	0.57	0.31	0.32	-0.41	-0.42	-0.28	0.65	*0.82	*0.72	**0.86	**0.95	1													
Nb loges	0.49	0.27	0.36	0.37	-0.26	0.2	0.2	0.03	0.26	0.22	0.38	0.42	-0.34	-0.62	-0.63	*-0.71	-0.16	0.28	0.55	*0.74	-0.17	-0.17	*0.80	0.46	0.51	-0.32	-0.44	-0.3	0.17	0.56	0.38	0.35	*0.72	0.61	1												
Circ,Ft 1Bq	*0.75	0.58	0.54	0.48	0.31	0.52	0.51	0.22	0.46	0.58	0.63	*0.66	0.49	0.12	0.17	0.03	-0.65	-0.39	0.08	0.34	0.24	0.24	0.65	0.44	0.48	-0.41	-0.47	-0.2	*0.72	*0.78	*0.68	**0.95	**0.93	**0.89	0.59	1											
Circ,Ft 2Bq	0.62	0.42	0.5	0.46	-0.03	0.37	0.41	0.52	*0.75	*0.77	**0.83	**0.84	0.22	-0.14	-0.19	-0.35	-0.35	-0.14	0.36	0.55	0.08	0.08	*0.71	0.46	0.5	-0.25	-0.43	-0.34	0.57	*0.78	0.58	*0.71	**0.92	**0.87	*0.72	*0.82	1										
Circ,Ft 3Bq	*0.77	0.58	0.56	0.51	0.27	0.51	0.49	0.15	0.42	0.52	0.6	*0.67	0.4	0.08	0.05	-0.1	-0.55	-0.41	0.11	0.34	0.28	0.28	*0.71	0.45	0.47	-0.34	-0.39	-0.2	*0.69	**0.87	*0.77	**0.86	**0.97	**0.98	*0.71	**0.92	**0.88	1									
Lg Ft 1Bq	*0.67	0.51	0.44	0.37	0.36	0.46	0.44	0.25	0.43	0.56	0.57	0.58	0.61	0.31	0.36	0.23	*-0.76	-0.55	-0.06	0.17	0.26	0.26	0.49	0.3	0.33	-0.46	-0.46	-0.19	*0.71	*0.72	0.65	**0.98	**0.88	**0.86	0.42	**0.98	*0.74	**0.86	1								
Lg Ft 2Bq	0.59	0.44	0.52	0.51	-0.01	0.38	0.4	0.14	0.42	0.47	0.6	*0.67	0.05	-0.39	-0.41	-0.5	-0.26	0.04	0.25	0.55	0.26	0.26	*0.79	0.54	0.64	-0.29	-0.58	-0.45	0.43	0.61	0.43	0.58	*0.81	*0.78	**0.85	*0.76	**0.88	**0.84	0.63	1							
Lg Ft 3Bq	0.63	0.41	0.39	0.32	0.14	0.34	0.33	0.35	0.53	0.57	0.61	0.64	0.42	0.2	0.14	-0.01	-0.64	-0.51	0.1	0.25	0.15	0.15	0.54	0.25	0.25	-0.42	-0.4	-0.27	0.61	**0.83	*0.71	**0.83	**0.95	**0.99	0.61	**0.87	**0.89	**0.96	**0.85	*0.74	1						
Pds 1 m(g)	0.17	0.13	0.11	0.15	-0.01	0.07	-0.02	*-0.74	-0.59	-0.57	-0.4	-0.28	-0.41	-0.46	-0.47	-0.41	0.05	0.22	0.04	0.17	0.11	0.11	0.38	0.2	0.23	-0.17	-0.15	-0.07	-0.17	0.08	0.11	-0.12	0.11	0.15	0.59	0.04	-0.01	0.24	-0.09	0.36	0.06	1					
Pds 2 m(g)	**0.91	*0.83	*0.81	*0.75	0.55	*0.80	*0.82	0.3	0.6	*0.77	*0.81	**0.84	0.62	0.3	0.31	0.08	-0.22	-0.38	0.26	0.36	0.22	0.22	*0.68	*0.67	0.59	0.2	0.18	0.36	**0.95	**0.95	**0.93	**0.83	*0.81	*0.72	0.32	*0.76	*0.70	*0.75	*0.73	0.47	*0.73	-0.19	1				
Yield/pt	**0.95	**0.83	*0.78	*0.73	0.62	*0.80	*0.79	0.14	0.42	0.60	0.64	*0.70	0.60	0.38	0.36	0.13	-0.10	-0.40	0.21	0.25	0.24	0.24	0.61	0.62	0.50	0.30	0.37	0.51	**0.91	**0.94	**0.98	*0.72	*0.71	*0.66	0.25	0.61	0.56	*0.69	0.59	0.34	*0.67	-0.10	**0.95	1			
Pr.mat.Bq 1	-0.06	-0.08	-0.06	-0.1	-0.05	-0.04	0.05	**0.83	*0.71	*0.66	0.5	0.37	0.36	0.43	0.42	0.32	-0.07	-0.22	0.15	-0.02	-0.27	-0.27	-0.25	-0.14	-0.21	0.17	0.22	0.15	0.23	0.11	0.05	0.18	0.04	-0.03	-0.44	0.03	0.14	-0.11	0.15	-0.3	0.09	**0.9	0.33	0.23	1		
Pr.mat.Bq 2	0.15	0.13	0.15	0.11	0.08	0.16	0.26	*0.81	*0.77	*0.78	0.65	0.53	0.45	0.4	0.41	0.28	-0.07	-0.21	0.21	0.1	-0.18	-0.18	-0.05	0.07	0	0.22	0.21	0.21	0.42	0.26	0.2	0.34	0.19	0.08	-0.33	0.2	0.27	0.03	0.29	-0.15	0.18	**-0.93	0.5	0.37	**0.97	1	
Pr.mat.Bq 3	0.25	0.21	0.23	0.19	0.11	0.24	0.33	*0.72	*0.71	*0.72	0.62	0.5	0.37	0.35	0.38	0.22	0.01	-0.14	0.36	0.21	-0.31	-0.31	0.04	0.15	0.05	0.31	0.39	0.42	0.45	0.35	0.32	0.31	0.2	0.04	-0.28	0.18	0.21	0.02	0.25	-0.22	0.15	**-0.83	0.56	0.46	**0.92	**0.96	1
Duréé mat	0.08	-0.02	0	-0.06	-0.09	-0.01	0.08	**0.91	**0.83	*0.78	0.64	0.51	0.42	0.39	0.38	0.26	-0.32	-0.31	0.16	0.09	-0.23	-0.23	-0.08	-0.1	-0.13	-0.09	-0.06	-0.07	0.34	0.29	0.17	0.43	0.33	0.27	-0.19	0.34	0.43	0.18	0.44	0	0.38	**-0.88	0.46	0.31	**0.94	**0.94	**0.87

(*) p < 0.05 one tailed test (**) p < 0.01 one tailed test

*Corresponding author, E-mail address: madjidboulgheb@gmail.com

Current Trends in Natural Sciences
Vol. 11, Issue 21, pp. 390-398, 2022
https://doi.org/10.47068/ctns.2022.v11i21.043
Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521
Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

For yield, positive correlations were recorded with the stem length and the number of leaves between every two successive clusters except for the first cluster, volume (length and diameter) and average weight of fruit, and earliness to flowering. Except for earliness to flowering which shows a very high and stable correlation with yield (above 0.8), we record a tendency of these characters to exhibit very strong correlations with yield during the early stages and then fall gradually with the advancement of the crop cycle and production (Table 5). This could be, to some extent, explained by the fact that the expression of the traits mentioned above is somewhat sensitive to the fast resumption of high temperature, especially high diurnal temperatures associated with intense luminosity from the beginning of March and which affects negatively and significantly the volume of matured fruits. Furthermore, the number of cherry fruits increases significantly with the evolution of the crop and increment of temperatures which is recorded by many authors (Shafiee**,** 2000**;** Agong et al., 2001; Henareh et al., 2015).

Regarding the mean weight of fruit, we remarked significant positive correlations with both stem length (distance between every two clusters), especially during the first stages of development, earliness to flowering notably from the 3rd clusters and the production and the mean weight of fruit of each cluster notably during first stages of the plant. Nevertheless, this character is negatively correlated with the number of flowers in each cluster. Additionally, as mentioned above, except for the correlation with the earliness to flowering, these correlations tend to decrease gradually with the crop evolution. For earliness to fruit maturity, we noticed strong positive and relatively stable correlations with earliness to flowering but a negative correlation with production during the early stage of development (1st month).

The principal component analysis (PCA) showed that the first four components generated more than 93 % (93.28 %) of the total found diversity, while six components account for the total variability i.e. 100 % (Table 6). In terms of the first component, it alone symbolizes 43.07% of the total variation, traits that had high coefficient values are the following; earliness to flowering, length of stem between every two clusters during the first stages of growth and rate growth monthly, length of the peduncle, number of flowers of the 3rd cluster, number of leaves between clusters, number of fruits picked up of clusters, the weight of cluster fruits picked up, mean weight of fruit of clusters, circumstance and length of fruit, and monthly production earliness to maturity of fruit from the 3rd cluster.

Table 6. Eigen values, cumulative variance % and principal components

Eigen values	Variance (%)	Cumulative Variance	Principal Component
20.68	43.07	43.07	1
9.17	19.10	62.17	2
7.79	16.23	78.40	3
7.14	14.89	93.28	4
2.32	4.83	98.11	5
0.91	1.89	100	6

The second component accounted for 19.10% of total diversity, while traits with higher scores were early to flowering, stem length between clusters, plant height after two months, the height of the 1st cluster, length of peduncle of 2nd cluster, number of flowers per cluster, number of leaves between

*Corresponding author, E-mail address: madjidboulgheb@gmail.com

clusters, number of fruits per cluster , the weight of fruits of 2nd cluster, number of fruits picked up per cluster, number of loges per fruit, circumstances of fruits, mean weight of fruit, earliness to maturity of fruits, the weight of fruits picked up per cluster, duration of maturity and yield.

The third principle component expressed 16.23 % of the whole variation, whereas characters with higher scores were earliness to maturity of 2nd cluster, stem length between clusters 1st - 2nd and 4th -5th, earliness to the flowering of the 1st cluster, length of peduncle of the two first cluster, number of flowers during very early stages, number of fruits of 2nd and 3rd clusters, number of picked up fruits of 3rd cluster, mean weight of fruits, mean weight of fruit, the length of fruit, and an average of maturation period of fruits and plant yield. Indeed, this component can be considered as a yield component. The yield has high positive and gradual correlations notably with height plant between every two clusters during crop evolution up to the fifth month and with earliness to flowering. The two first components analysis elucidated 62.17 % of total variations among genotypes (Table 6) and 32 characters are well expressed.

In terms of dendrogram analysis, according to genetic and geographic factors, it displays the presence of 03 groups (Figure 1) of which, the first one enumerates four varieties, namely, V 1, V 3, V 4, and V 6, the second group comprises of two varieties i.e. V 2 and V5, meanwhile the last group account for one variety, namely, V 7. Furthermore, V 1 is the most similar to V 4 among these genotypes and they have the lowest dissimilarity value. This group has high similarities with V 3 and is followed by V 6.

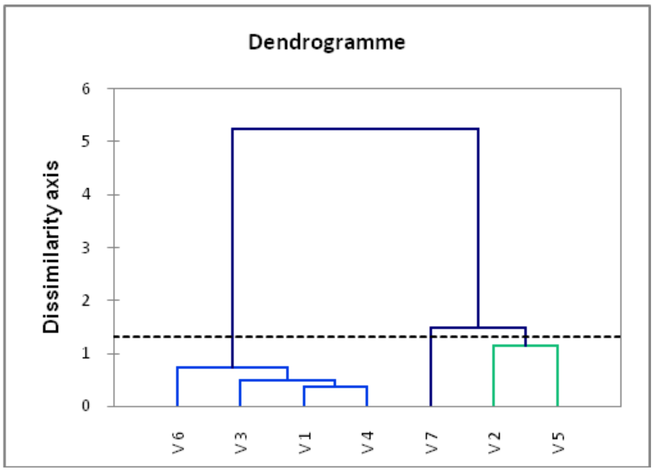

Figure 1. The genetic distance dendrogram showing the classification of 7 tomato genotypes in 2018

4. CONCLUSION

Due to its diverse use, the tomato is one of the most widely practiced crops. Through this study, we tried to determine the genetic variation within these cultivars. The principal component analysis showed that selection for speed stem growth during early stages, earliness to flowering for late clusters, number of leaves for the early clusters, and fruit growth rate during early stages have an important positive impact on yield differences.

Finally, more extended trials to other adaptation characters and molecular markers for more concluded results are highly recommended in such conditions i.e. agro-ecological management especially, to draw up presumably a research program for hybridization and selection.

*Corresponding author, E-mail address: madjidboulgheb@gmail.com

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

5. ACKNOWLEDGEMENTS

Authors are particularly indebted to Pr. Iddou AEK from Adrar University, for helpful suggestions, discussions, and painful reading of the final copy.

6. REFERENCES

Agong, S.G. , Schittenhelm, S., Fried, W. (2001). Genotypic variation of Kenyan tomato (*Lycopersicon esculentum* Mill.) germplasm. *J. Food Tech. Africa*, 6, 13-17.

Al Aysh, F., Kutma H., Serhan, M., Al-Zoubai, A., Abdelsalam, Al-Naseer, M. (2012). Genetic analysis and correlation studies of yield and fruit quality traits in tomato (*Solanum lycopersicum* L.). *New York Science Journal*, 5, 142-145.

Bai, Y., Lindhout, P. (2007). Domestication and breeding of tomatoes: What have we gained and what can We gain in the future. *Annals of Botany*, *100*(5), 1085–1094. Retrieved January 16, 2018, from http://doi.org/10.1093/aob/mcm150.

Beecher, G. R. (1998). Nutrient content of tomatoes and tomato pro-ducts, *Proc. Soc. Exp. Biol. Med*., 218, 98 –100.

Chernet, S., Belew, D., Abay, F. (2014). Genetic diversity studies for quantitative traits of tomato (*Solanum lycopersicon* L.) genotypes in Western Tigray, Northern Ethiopia. *Journal of Plant Breeding and Crop Science*, *6*(9), 105-113. Retrieved January 16, 2018, from http://doi.org/10.58 97/JPBCS2014.047.

FAO. (2010). Food and agriculture organization of the United Nations statistical databases. Retrieved January 16, 2018, from http://faostat.fao.org/

FAOSTAT. (2018). FAOSTAT Statistics division**,** Food and Agriculture Organization of the United Nations, Rome, www.fao.org/faostat/en/#data (2018), Accessed 19th May 2019.

Foolad, R.M. (2007). Genome mapping and molecular breeding of tomato. *Int. J. Plant Genomics*. Vol 2007: Article ID 64358, p. 52. DOI: 10.1155/2007/64358.

Henareh, M., Dursun, A., Mandoulakani, B.A. (2015). Genetic diversity in tomato landraces collected from Turkey and Iran revealed by morphological characters. *Acta Scientiarum Polonorum Hortorum Cultus*, 14(2), 87-96.

Herison, C., Sutjahjo, H.S., Sulastrini, I., Rustikawat R., Marwiya, S. (2018). Genetic Diversity Analysis in 27 Tomato Accessions Using Morphological and Molecular Markers. AGRIVITA *Journal of Agricultural Science*. 40(1), 36-44.

Kaur, S., Cogan, N. O. I., Forster, J. W., Paull, J. G. (2014). Assessment of genetic diversity in faba bean based on single nucleotide polymorphism. *Diversity*, *6*(1), 88–101. Retrieved January 18, 2018, from http://doi.org/10.3390/d6 010088

Latigui, A. (1984). Effets des différents niveaux de fertilisation potassique sur la fructification de la tomate cultivée en hiver sous serre non chauffée [Effects of different level s of potassium fertilization on the fruiting of tomato grown in winter in an unheated greenhouse. Master's thesis]. Thèse de magister. INRA El-Harrach ,Algérie.

Li, T. S. C. (2008). Vegetables and fruits: Nutritional and therapeutic values. Boca Raton, USA: CRC Press.

MADR, 2009. Statistiques agricoles [Agricultural statistics], Série B : 64 p.

Mazzucato, A., Papa, R., Bitocchi, E., Mosconi, P., Nanni, L., Negri, V., Picarella, M.E., Siligato, F., Soressi, G.P., Tiranti, B., Veronesi, F. (2008). Genetic diversity, structure and marker-trait associations in a collection of Italian tomato (*Solanum lycopersicum* L.) landraces. *Theor. Appl. Genet*. 116 (5), 657–669. Retrieved January 15, 2018, from http://dx.doi.org/10.1007/s00122-007-0699-6.

Mekhlouf, A., Dehbi, F., Bouzerzour, H., Hannchi, A., Benmahammed, A., Adjabi, A. (2006). Relationships between cold tolerance, grain yield performance and stability of durum wheat (*Triticum durum* Desf.) genotypes grown at high elevation area of Eastern Algeria. *Asian Journal of Plant Sciences*, *5*(4), 700–708. Retrieved February 18, 2018, from http://doi.org/10.3923/ajps.2006.700.708 .

Merk, H. L., Yarnes, S. C., van Deynze, A., Tong, N., Menda, N., Mueller, L. A., Francis, D. M. (2012). Trait diversity and potential for selection indices based on variation among regionally adapted processing tomato germplasm. *Journal of the Amercian Society for Horticultural Science*, 137(6), 427–437. Retrieved January 20, 2018, from http://journal. ashspublications.org/content/137/6/427.abstract.

Mwirigi, P.N., Kahangi, E.M., Nyende, A.B., Mamati, E.G. (2009). Morphological variability within the Kenyan yam (Dioscorea spp.). *J. Appl. Biosci*., 16, 894–901.

Osei, M.K., Bonsu, K.O., Agyeman, A. Choi, H.S. (2014). Genetic Diversity of Tomato Germplasm in Ghana using Morphological Characters. *International Journal of Plant and Soil Science*, 3(3), 220-231.

*Corresponding author, E-mail address: madjidboulgheb@gmail.com

Current Trends in Natural Sciences
Vol. 11, Issue 21, pp. 390-398, 2022
https://doi.org/10.47068/ctns.2022.v11i21.043
Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521
Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

Peralta, I.E, Spooner, D.M. (2007). History, origin and early cultivation of tomato (Solanaceae). In: Razdan, M.K., Mattoo, A.K. (2005). *Genetic improvement of solanaceous crops.* Vol. 2. Tomato. Enfield, NH: *Science Publishers*, 1– 27.

Poczai, P., Varga, I., Bell, N. E., Hyvönen, J. (2011). Genetic diversity assessment of bittersweet (*Solanum dulcamara*, Solanaceae) germplasm using conserved DNA-derived polymorphism and intron-targeting markers. *Annals of Applied Biology*, 159(1), 141–153. Retrieved January 18, 2018, from http://doi.org/10.1111/j.1744-7348.2011.00482.x

Pu, Z. E., Hou, Y. C., Xu, X. X., Yan, Z. H., Wei, Y. M., Lan, X. J., Zheng, Y. L. (2009). Genetic diversity among barley populations from West China based on RAMP and RAPD markers. *Asian Journal of Plant Sciences*, 8(2), 111–119. Retrieved January 15, 2018, from http:// doi.org/10.3923/ajps.2009.111.119.

Raffo, A., Leonardi, C., Fogliano, V., Ambrosino, P. **(**2002). Nutritional value of cherry tomatoes (*Lycopersicon esculentum* cv. Naomi F1) harvested at different ripening stages, *J.Agric. Food Chem*. 50, 6550 –6556.

Reddy, B.R., Reddy, M.P, Begum, H, Sunil, N. (2013). Genetic diversity studies in tomato (*Solanum lycopersicon* L.). Int. Org. Scient. Res. *J. Agricult. Vet. Sci.*, 4(4), 53-55.

Redden, R., Yadav, S. S., Maxted, N., Dulloo, M. E., Guarino, L., Smith, P. (2015). Crop wild relatives and climate change. Retrieved January 16, 2018, from http://ysu.am/files/CWR-NELLI, HOVHANNISYAN.pdf

Shafiee, R. (2000). Study of agronomic character and grouping of tomato breeding lines. The second Horticultural Sciences Congress of Iran, Karaj, Iran.***in*** Mashhid Henareh , Atilla Dursun , Babak Abdoullahi, Mandoulakani (2015). Genetic diversity in tomato landraces collected from Turkey and Iiran revealed by morphological characters. *Acta Sci. Pol. Hortorum Cultus*, 14(2), 87-96.

Sharifova, S, Mehdiyeva, S, Theodorikas, K, Roubos, K. (2013). Assessment of genetic diversity in cultivated tomato (*solanum lycopersicum* l.) Genotypes using RAPD primers. *J. of Horticultural Research*, 21(1), 83-89.

Steel, R. G. D. Torrie, J. H. (1980). Principles and procedures of statistics: a biometrical approach. 2nd ed. 633 p. McGraw-Hill book Co., Inc., New York.

Steel, R.G.D, Torrie, J.H. (1982). Principles and procedures of statistics. 420 p. McGraw-Hill book Co., Inc., New York.

*Corresponding author, E-mail address: madjidboulgheb@gmail.com