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Genetic variability and correlation studies in olive (*Oleaeuropea* L.) genotypes under mid hills conditions of Jammu and Kashmir, India

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ABSTRACT

The present investigation for assessment of genetic variability on horticultural traits in sixteen olive genotypes was carried out at experimental farm of Advance Centre for Horticulture Development, Govindpura, Ramban (Jammu and Kashmir). All the selected genotypes differed significantly for the selected traits. Twenty traits were scored and subjected to genetic variability analysis. Highest phenotypic coefficient of variation was observed for plant volume (57.87 %), pulp weight (34.06 %) and fruit weight (32.88 %) followed by moderate PCV values for leaf area (27.62 %), stone weight (26.60 %), plant spread (24.26 %), yield (20.61 %), number of fruiting shoot (20.01 %). High heritability coupled with high genetic advance was found for the character plant volume, TSS, yield and oil content. Correlation coefficient between the characteristics suggested that there were some significant correlations among a number of measured characteristics. A significant and positive correlation was observed between leaf and fruit characters. Plant spread (-0.685), plant volume (-0.679), leaf length (-0.594), fruit length (-0.733), fruit diameter (-0.788), fruit weight (-0.783), pulp weight (-0.769), stone diameter (-0.637), stone weight (-0.841) showed negative but highly significant correlation with oil content. Among genotypes most diverse genotypes were Nocellara Messinese, Leccino and Cipressino which could be utilized as donor parents breeding programs which may result in increase in the desired traits such as fruit size, oil content and yield.

Key words : *Olive, Genotypes, Genetic variability, Heritability, Correlation, Kashmir*

Introduction

Olive tree was considered a sacred tree, a symbol of peace and spring of resources. It was affirmed that olive tree is native to Mediterranean region (Syria, Lebanon, Palestine) from where it spread to worldwide (Youssef, 2008). It is one of the most important and the world's oldest cultivated crop which is consumed as a source of oil and for table consumption (Orlandi *et al.*, 2004). Olive oil has favorable nutritional properties, and as a result, its consumption, traditionally restricted to the Mediterranean area (77% of the world production area), is increasing worldwide (mainly United States, Canada, Australia and Japan). It has a tremendous scope and potential in India especially in mid hills and warm temperate regions of North Western Himalaya (Lal *et al.*, 2017). In-spite of its vast potential it is only grown in the Himalayan mountainous region encompassing the three northern states viz. Jammu and Kashmir, Himachal Pradesh and Uttarakhand at an altitude ranging from 1000 to 1300 m above mean sea level and also to small scale in Rajasthan. In India, the demand of olive is increasing rapidly due to its peculiar medicinal and antioxidental properties (IOOC, 2011) but indigenous olive species has low fruit yield and oil content (Joshi, 2011). Some varieties are cultivated specifically for table consumption, but the majority is used for oil extraction. The genetic diversity could be an important resource for the development of modern olive culture towards typical olive oil and fresh productions. Estimation of genetic variability present in the germplasm of a crop is a pre-requisite for designing effective breeding programme (Parkash, 2012). However, utilization of this variability requires its systematic evaluation to understand and to estimate the genetic variability, heritability and genetic advance of various yield and physiochemical components. Therefore, prior to recommendation of new cultivars, they should be tested and extent of variability present must be adequately assessed so that they perform consistently over a long period of time. The present investigation to estimate the extent of genetic variability, heritability and correlation among sixteen diverse genotypes of olive for various compositional and yield attributes for identifying superior genotypes for involvement in future breeding programme.

Materials and Methods

Present investigation was carried out on sixteen olive varieties having twenty year of age at the Advance Centre for Horticulture Development, Govindpura, Ramban (Jammu and Kashmir) during the years 2014 and 2015. The research farm at Ramban is situated at a latitude of 33°14′N and longitude of 75°17′E and at an altitude of 1156 m above mean sea level. Recommended package of practices were followed for healthy crop. The average maximum(40-42°C) and minimum (15-16°C) temperature with a rainfall of 268 mm was recorded during the study.

The plants were planted at a distance of 5.0 x 5.0 m. The observations on various vegetative, foliage, fruit, stone, oil and yieldwere recorded. Plant height and plant spread (on both sides) was measured with the help of measuring pole however plant volume was calculated from the height and spread measurement according to the formula given by Westwood (1993). Ten mature leaf sample and fully ripened twenty fruits from each genotype were randomly collected during July and November, respectively for observations. The length and diameter of leaf and fruits were measured by digital Vernier caliper. Fruit weight was measured using digital sartorius balance with accuracy of 0.001 g. The stones were manually separated from the ripe fruits and pulp and stone characteristics were also measured. The yield per plant has been recorded over the study period by counting number of fruits and multiplying with average fruit weight. Oil content on dry weight basis was estimated using standard soxhlet method.

Standard procedures were followed to analyze the data statistically as suggested by Panse and Sukhatme (1985). The genotypic and phenotypic coefficients of variation were worked out as per procedure described by Singh (2003). Heritability in broad sense and expected genetic advance were calculated as per the formula given by Allard (1999) and Johnson *et al.* (1955), respectively. The correlation coefficient was calculated for all the characters with fruit yield and among the characters themselves as suggested by Al-Jibouri *et al.* (1958).

Results and Discussion

The extent of variability present in the genotypes was measured in terms of range, mean, coefficient of variation, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad sense heritability, genetic advance and genetic gain (Table 1). It was found that moderate to high range of variation was recorded in all the studied characters, indicating better scope for improvement. Plant height and plant spread ranged between 4.15 m (Azapa and Coratina) and 5.61 m (Itrana) and 2.30 m (Ottobratica) and 4.36 m (Itrana) with a mean value of 4.81 and 3.04, respectively. The coefficient of variation for plant height and plant spread was 3.96 and 3.31, respectively. Leccino (12.45 m^3) and Nocellara del Belice (9.84) recorded minimum plant volume and number of fruiting shoots, respectively whereas maximum plant volume and number of fruiting shoots was recorded in Itrana (55.93 m^3) and Cipressino (18.49), respectively (Table 1 and Fig. 1). Average mean values and coefficient of variation for plant volume (25.40 m^3 and

0.82 %) and number of fruit shoot (12.58 m^3 and 0.71 %), respectively. Maximum values for leaf length, leaf breadth and leaf area was recorded in Nocellara Messinese (7.46 cm), Nocellara del Belice (1.53 cm) and Nocellara del Belice (8.60 cm^2) whereas minimum leaf length, leaf breadth and leaf area was recorded in Ottobratica (3.72 cm), Nocellara Etnea (0.98 cm) and Ottobratica (3.10 cm^2). Mean values and coefficient of variation for leaf length, leaf breadth and leaf area was 5.89 cm and 2.13 %, 1.20 cm and 2.30 % and 5.79 cm^2 and 11.72 %, respectively. Similar types of variability for growth and foliage parameters have been reported by Hermoso *et al*. (2014); Arquero *et al*. (2014) and Lal *et al.* (2017).

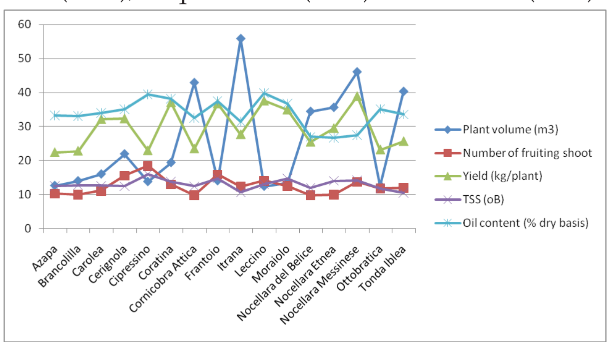

Fig. 1. Plant volume, number of fruiting shoot, yield, oil content (dry weight basis) and total soluble soilds of different olive cultivars

Fruit length and fruit breadth varied from 19.87 mm (Cipressino) to 31.34 mm (Nocellara Messinese) and 14.25 mm (Ottobratica) to 21.45 mm (Nocellara Messinese) with a mean value of 24.78 mm and 17.33 mm, respectively (Table 1 and Fig 2). The coefficient of variation for fruit length and fruit breadth was 3.19 and 0.81 respectively. Nocellaradel Belice (1.26) and Azapa (1.58) scored minimum and maximum L/D ratio with a mean value and coefficient of variation of 1.43 and 2.93, respectively. Cipressino recorded minimum values for fruit weight (2.83 g), pulp weight (2.41 g) and stone weight (0.42 g) whereas Nocellara Messinese registered maximum values for fruit weight (8.05 g), pulp weight (7.15 g) and stone weight (0.90 g). Mean value and coefficient was fruit weight (4.54 g and 1.81%), pulp weight (3.95 g and 2.57 %) and stone weight (0.61 g and 2.89%), respectively. Pulp/stone ratio ranged between 5.34 g (Azapa) and 8.29 g (Frantoio) with a mean value of 6.48 and coefficient of variation was 5.42 per cent. Minimum stone length and stone diameter was recorded in Cipressino (14.10 mm) and Frantoio (6.44 mm) whereas maximum stone length and stone diameter was measured in Nocellara Etnea (21.16 mm) and Nocellara Messinese (11.15 mm), respectively. Mean value and coefficient of variation was stone length

Table 1. Genetic variability components for major characters in olive varieties

Characters	Range	Mean	CoV	Coefficient of variation (%)		Heritabilit (%)	Genetic advance	Genetic gain (%)
				GCV	PCV			
Plant height (m)	4.15-5.61	4.81	3.96	10.67	11.38	87.9	0.99	20.62
Plant spread (m)	2.30-4.36	3.04	3.31	24.03	24.26	88.1	1.49	49.05
Plant volume (m^3)	12.45-55.93	25.40	0.82	57.87	57.87	99.9	30.28	119.20
Number of fruiting shoot	9.84-18.49	12.58	0.71	20.00	20.01	99.8	5.18	41.18
Leaf length (cm)	3.72-7.46	5.89	2.13	17.56	17.69	88.5	2.12	35.92
Leaf breath (cm)	0.98-1.53	1.20	2.30	12.46	12.67	86.7	0.30	25.26
Leaf area (cm^2)	3.10-8.60	5.79	11.72	25.00	27.62	81.9	2.70	46.65
Fruit length (mm)	19.87-31.34	24.78	3.19	13.87	14.23	94.9	6.90	27.86
Fruit diameter (mm)	14.25-21.45	17.33	0.81	15.24	15.26	99.7	5.43	31.35
L/D ratio of fruit	1.26-1.58	1.43	2.93	7.44	7.99	86.6	0.20	14.26
Fruit weight (g)	2.83-8.05	4.54	1.81	32.83	32.88	99.6	3.07	67.54
Pulp weight (g)	2.41-7.15	3.95	2.57	33.96	34.06	99.4	2.76	69.77
Pulp/stone ratio	5.34-8.29	6.48	5.42	13.49	14.53	86.1	1.67	25.79
Stone length (mm)	14.10-21.16	17.26	0.27	9.88	9.89	89.9	3.52	20.36
Stone diameter (mm)	6.44-11.15	8.28	0.41	12.81	12.82	91.9	2.19	26.39
Stone weight (g)	0.42-0.90	0.61	2.89	26.44	26.60	88.2	0.33	54.16
pH of fruit juice	5.37-5.62	5.45	1.12	1.28	1.70	56.81	0.11	1.99
TSS (°B)	10.53-16.07	13.06	1.03	11.49	11.53	99.2	11.08	84.84
Yield (kg/plant)	22.46-38.90	29.58	2.35	20.48	20.61	98.7	12.40	41.92
Oil content (% dry basis)	26.70-39.90	33.84	1.35	12.30	12.37	98.8	8.53	54.75

(17.26 mm and 0.27 %) and stone diameter (8.28 mm and 0.41%), respectively. The results pertaining to fruit and stone characters studied presently are in accordance with the findings of Rio *et al.* (2008), Arslan (2012) and Jalali *et al.* (2014).

pH of the juice and TSS varied from 5.37 (*Brancolilla* and *Nocellara etnea*) to 5.62 (Coratina) and 10.53°B (Tonda Iblea) to 16.07°B (*Cipressino*) with a mean value of 5.45 and 13.06°B and coefficient of variation was 1.12 per cent and 1.03 per cent, respectively (Table 1 and Fig 1). Azapa (22.46 kg/plant) recorded minimum yield whereas maximum yield was observed in NocellaraMessinese (38.90 kg/plant). Mean values and coefficient of variation for yield was 29.58 kg/plant and 2.35 per cent, respectively. Oil content ranged between 26.70 per cent (Nocellara Etnea) and 39.90 per cent (Leccino) with a mean value of 33.84 per cent and coefficient of variation was 1.35 per cent. In the previous studies, Rio *et al.* (2008), Hermoso *et al*. (2014) and Lal *et al.* (2017) also reported similar results.

Perusal of data presented in Table 1 revealed that magnitude of phenotypic coefficient of variation have higher values than genotypic coefficient of variation for all the traits studied, though with narrow difference for most of the characters which indicates that these are less influenced by environmental factors. Highest phenotypic coefficient of variation was observed for plant volume (57.87 %), pulp weight (34.06 %) and fruit weight (32.88 %) followed by moderate PCV values for leaf area (27.62 %), stone weight (26.60 %), plant spread (24.26 %), yield (20.61 %), number of fruiting shoot (20.01 %) indicating the existence of substantial variability pointing ample scope for their improvement through selection. Lower values of GCV than PCV indicated close association between phenotype and genotype. Present results are in agreement with those reported by Singh *et al.* (2009); Dogra *et al.* (2018) in walnut and Gond *et al.* (2019) in Water chestnut.

Heritability is a parameter of tremendous significance to the breeders as its magnitude indicates the reliability with which a genotype can be recognized through its phenotypic expression (Table 1). Johnson *et al.* (1955) stressed that for estimating the real effect of selection, heritability estimates along with genetic advance are more meaningful. High heritability estimates in broad sense was observed for plant volume (99.9 %), number of fruiting shoots (99.8 %), fruit length (94.9 %), fruit diameter (99.7 %), fruit weight (99.6 %), pulp weight (99.4 %), TSS (99.2 %), yield (98.7 %) and oil content (98.8 %). High genetic coefficient of variance along with high heritability and high genetic advance provides better information than single parameters alone (Baye *et al.*, 2005). Heritability estimates alone are not an ideal parameter for predicting the effect of selecting the desired individual. Heritability estimates along with genetic advance are more useful than heritability values alone in predicting the selection of best individuals. In the present study, plant volume, TSS, yield and oil content exhibited high genetic advance as percentage of mean along with high heritability. These results indicated the influence of additive gene action. In general, the characters which showed high heritability with high genetic advance as per cent of mean are genetically controlled by additive gene (Panse, 1957) and can be improved through mass selection, progeny selection or any other modified selection procedures.

Correlation studies

Genotypic correlation of twenty yield and yield attributing characters showed that most of the correlation coefficients at genotypic level were greater than on the corresponding phenotypic level (Table 2). This suggested the predominance of genotypic effects over environmental factors. The variation in correlation coefficient may be due to heterogeneous population having differences in genetic makeup of individual trees. Plant height was positively and highly significantly correlated with plant spread (0.831), plant volume (0.869), leaf length (0.520), fruit diameter (0.553), stone diameter (0.499) whereas negatively but highly significantly correlated with TSS (-0.529) and yield (-0.726) at genotypic level. Highly significant and positive correlation was observed between plant spread and plant volume (0.992), leaf length (0.645), fruit diameter

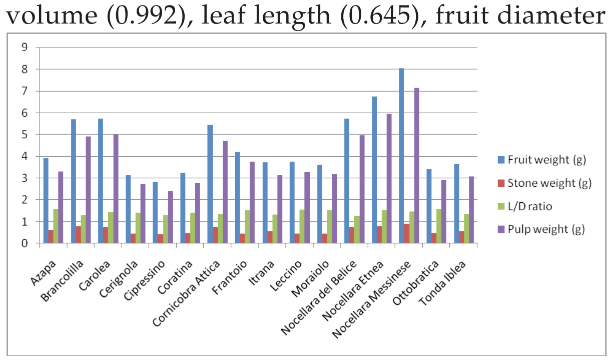

Fig. 2. Fruit weight, stone weight, L/D ratio and pulp weight of different olive cultivars

Table 2. Correlation coefficient (genotypic) among different characters in olive varieties

Characters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.000	0.831**	0.869**	-0.188	0.520*	0.101	0.289	0.401	0.553*	-0.410	0.416	0.410	0.071	0.355	0.499*	0.436	-0.187	-0.529*	-0.726**	-0.058
2			0.992**	-0.300	0.645**	0.304	0.441	0.394	0.566*	-0.467	0.443	0.426	-0.075	0.284	0.613*	0.517*	0.087	-0.391	-0.041	-0.685**
3				-0.268	0.608*	0.228	0.390	0.396	0.553*	-0.432	0.424	0.408	-0.066	0.302	0.647**	0.491	0.031	-0.430	-0.051	-0.679**
4					-0.251	-0.445	-0.313	-0.498*	-0.502*	0.028	-0.466	-0.439	0.155	-0.427	-0.306	-0.654**	0.187	0.538*	0.371	0.615*
5						0.427	0.858**	0.540*	0.643**	-0.350	0.594*	0.582*	0.115	0.403	0.596*	0.635**	0.316	-0.140	0.240	-0.594*
6							0.641**	0.141	0.334	-0.373	0.243	0.219	-0.231	-0.081	0.191	0.412	0.238	-0.304	-0.143	-0.230
7								0.483*	0.541*	-0.214	0.576*	0.573*	0.249	0.273	0.531*	0.580*	0.480	-0.007	0.391	-0.496
8									0.875**	0.091	0.959**	0.960**	0.626**	0.900**	0.565*	0.874**	-0.060	0.031	0.148	-0.733**
9										-0.418	0.912**	0.901**	0.369	0.648**	0.579*	0.928**	-0.203	-0.095	-0.080	-0.788**
10											-0.081	-0.058	0.410	0.334	-0.140	-0.261	0.301	0.210	0.404	0.235
11												0.999**	0.563*	0.733**	0.619*	0.939**	-0.002	0.079	0.132	-0.783**
12													0.598*	0.739**	0.604*	0.923**	0.007	0.109	0.167	-0.769**
13														0.657**	0.042	0.255	0.156	0.523*	0.695**	-0.164
14															0.371	0.605*	-0.005	-0.063	0.258	-0.535*
15																0.667**	0.195	-0.233	0.046	-0.637**
16																	-0.085	-0.144	-0.138	-0.841**
17																		0.069	0.707**	0.282
18																			0.378	0.304
19																				0.196
20																				1.000

**Significant at 1 per cent, *Significant at 5 per cent

1 Plant height (m); 2 Plant spread (m); 3 Plant volume (m3); 4 Number of fruiting shoot; 5 Leaf length (cm); 6 Leaf breadth (cm); 7 Leaf area (cm2); 8 Fruit length (mm); 9 Fruit diameter (mm); 10 L/D ratio of fruit; 11 Fruit weight (g); 12 Pulp weight (g); 13 Pulp/stone ratio; 14 Stone length (mm); 15 Stone diameter (mm); 16 Stone weight (g); 17 pH of fruit juice, 18 TSS (oB); 19 Yield (kg/plant); 20 Oil content (%) dry basis

(0.566), stone diameter (0.613) and stone weight (0.517) however plant spread showed negative and significant correlation with oil content (-0.685). In the previous study, Rosati *et al.* (2017) reported that growth characters were correlated with leaf and fruit characters whereas inversely correlated with yield.

At genotypic level plant volume had positive and significant correlation with leaf length (0.608), fruit diameter (0.553), stone diameter (0.647) and stone weight (0.491) however negative and highly significantly correlated with oil content (-0.679). Number of fruiting shoot showed positive and significant correlation with TSS (0.538) and oil content (0.615) whereas negatively and significantly correlated with fruit length (-0.498), fruit diameter (-0.502) and stone weight (-0.654). Leaf length had positive and highly significant correlation with leaf area (0.858), fruit length (0.540), fruit diameter (0.643), fruit weight (0.594), pulp weight (0.582), stone diameter (0.596) and stone weight (0.635) at genotypic level however negatively but significantly correlated with oil content (-0.594). Leaf breadth showed positive and highly significant correlation with leaf area (0.641). Leaf area was positively and significantly correlated with fruit diameter (0.541), fruit weight (0.576), pulp weight (0.573), stone diameter (0.531) and stone weight (0.580). A significant and positive correlation was observed between fruit and leaf characters (Jalali *et al.*, 2014).

Fruit length had positive and highly significant correlation with fruit diameter (0.875), fruit weight (0.959), pulp weight

(0.960), pulp/stone ratio (0.626), stone length (0.900), stone diameter (0.565) and stone weight (0.874) however negatively but significantly correlated with oil content (-0.733). Highly significant and positive correlation was observed between fruit diameter and fruit weight (0.912), pulp weight (0.901), stone length (0.648), stone diameter (0.579) and stone weight (0.928) whereas negatively but significantly correlated with oil content (-0.788). Fruit weight had positive and highly significant correlation with pulp weight (0.999), pulp/stone ratio (0.563), stone length (0.733), stone diameter (0.619) and stone weight (0.939) at genotypic level whereas negatively but significantly correlated with oil content (-0.783).

Pulp weight was positively and significantly correlated with pulp/stone ratio (0.598), stone length (0.739), stone diameter (0.604) and stone weight (0.923) however negatively and significantly correlated with oil content (-0.769). Pulp/stone ratio showed significant and positive correlation with stone length (0.657), TSS (0.523) and yield (0.695) whereas stone length was positively and significantly correlated with stone weight (0.605) at genotypic level and had negative but significant correlation with oil content (-0.535). Positive and highly significantly correlation was observed between stone diameter and stone weight (0.667) whereas stone diameter and stone weight showed negatively but highly significantly correlation with oil content (-0.637 and -0.841), respectively at genotypic level. Yield was positively and highly significantly correlated with pH of fruit juice (0.707).

Conclusion

Sufficient genetic variability among genotypes was observed for all the traits especially for plant volume, fruit weight, stone weight, total soluble solids, yield and oil content which also showed high heritability along with high to moderate genetic gain, thereby, indicating the additive gene action for these traits and hence simple selection procedure based on phenotypic expression of these traits would be more reliable. Beside this, these traits had shown significant and positive genotypic correlation with each other which revealed the inherent relationship among them.

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