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Assessment of genetic diversity, variability and character association in *Trachyspermum ammi* L.

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Abstract
Twenty six *Trachyspermum ammi* gentoypes were evaluated in *Rabi* 2020 at Chilli and Vegetabile Research Unit (CVRU), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) for estimates of genetic diversity and correlation coefficients for thirteen morphological traits by laying down the field experiment in randomized block design with three replications. The observations were recorded for thirteen important yield and yield contributing traits. Genotypes, PDKV AJ 11 and PDKV AJ 10 found high potential for seed yield, whereas PDKV AJ 14, PDKV AJ 19 and PDKV AJ 02 were the early maturing genotypes. Based on the D^2 estimates these twenty-six genotypes were grouped into four clusters, cluster III comprised maximum number of genotypes (nine) followed by cluster I and cluster IV which comprised six genotypes while cluster II included only five genotypes. Analysis of variance indicated significant differences among the genotypes for all the traits under study. The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV). High heritability was observed for test weight followed by number of umbels per plant, seed yield per plant, days to first flowering, number of seeds per umbel, number of umbellate per umbel and days to 50 per cent flowering. The high genetic advance was observed for number of seeds per umbel, number of umbels per plant, days to first flowering and plant height at maturity. Seed yield per plant was significant and positively correlated with days to first flowering, days to 50 per cent flowering, number of primary branches per plant, number of seeds per umbel, number of umbels and test weight.

Keywords: Genotypes, umbels, flowering, higher

Introduction
Ajwain i.e. *Trachyspermum ammi* L. (Apiaceae) is an erect yearly herb having the striate stem, India and eastern Persia has been identified as the origin. The little fruit is most important plant part like caraway, which always especially part of Indian delectable recipes, flavorful baked goods, and snacks. In field of Ayurvedic medicines, ajwain is used as a restorative plant for its stimulant, carminative, antispasmodic, and tonic properties since long time (Singh *et al*., 2002) [21]. Due to characteristic odor of ajwain combined with sharp tastes is employed in curries as a flavor and moreover the seeds are utilized as flavoring agents in foods as preservatives, also for the manufacture of vital oil in perfume industry. In general practice, ajwain is grown in arid or partially arid regions, it is very easy to grow. It can be grown as a hedge in a small garden as it is quite prolific and fills up really fast. Commercially, *Ajwain* is generally grown from seeds during rabi season starting from October to November which is the ideal for sowing the seeds.
A general understanding of the genetic relationships through estimates of genetic diversity and variability is crucial for preserving the biodiversity of this medicinal and aromatic plant. Beside this, the industrial benefits of ajwain may be assured if proper potent germplasm lines among available genepool are selected that yield not only high genetic distances but also such characters of high commercial value for its industrial applicability as high essential oil content, seed yield, and 1000 seed weight etc., Hence, the present investigation is carried out to assess the genetic divergence, genetic variability along with correlation coefficients among twenty-six elite germplasm lines of ajwain.

Materials and Methods
An experiment with twenty six lines of Ajwain, out of which twenty-two genotypes were collected from Chilli and Vegetable Research Unit (CVRU), Dr. PDKV, Akola among those four varieties *viz.*, AA-19-01, AA-2, PKV 07 and AA-93 were collected from National Research Centre on Seed Spices (NRCSS), Ajmer (Rajasthan) was carried out to estimate the

genetic diversity, genetic variability and correlation using data on thirteen yield and yield contributing traits grown in randomized block design with three replications during Rabi season of 2020.

The analysis of variance was performed to test the significance of differences among the genotypes for all the traits under study. The analysis of variance was carried out as per standard method (Panse and Sukhatme, 1967) [16]. The D^2 values were obtained as follows (Mahalanobis 1936) [12] and subsequent clustering was carried out by the Tocher's method as described by Rao (1952) [17]. The coefficient of variation was determined according to Burton (1952). Heritability in broad sense was determined by formula given by Lush (1949). Genetic advance was calculated according to formula given by Johnson *et al*. (1955a) [7]. The correlation coefficient was worked out as per the formula given by Johnson *et al.* (1955b) [6]. The technique of path coefficient analysis was devloped by Wright (1921) [26]. The use of this technique requires a cause and effect situation among the variables (Dewey and Lu, 1959) [3] by solving simultaneous equations, which express the basic relationship between path coefficient and correlation coefficient.

Results and Discussion

The findings of analysis of variance for all thirteen yield and yield attributing characters studied were found statistically highly significant, indicating the presence of substantial genetic variability in the experimental material.

The mean performance of genotypes twenty-six ajwain for thirteen characters gives the general view of genotype (Table 1). Wide ranges of variation were observed for all the thirteen characters among twenty-six ajwain genotypes in present investigation. The range of variation was the highest for number of seeds per umbel (147.50-424.98), number of umbels per plant (30.24-119.24), plant height at maturity (75.57-118.33), days to first flowering (61.67-92.33), days to 50 per cent flowering (82.00-110.67), days to maturity (129.67-144.67), number of seeds per umbellate (11.33-22.28), seed yield per plant (3.02-8.29), number of umbellate per umbel (9.31-16.46), number of primary branches per plant (8.42-13.19), while it was found in lower magnitude for length of first internode (1.77-3.38) and diameter of main umbel (3.03-4.23) and test weight (0.52-1.42). The comparison of mean performance using mean values of each genotype revealed very high level of variability in the genotypes included in experimental material. The genotype PDKV AJ 11 (8.29 g) was recorded the highest seed yield per plant followed by PDKV AJ 10 (8.16 g). Most of genotypes were found yielding higher seed yield per plant over general mean. These findings of mean performance of various characters are also in agreement with findings of Ghanshyam *et al*. (2014) [5], Meena *et al*. (2014) [13, 14] in coriander, Subramaniyan *et al*. (2018) [22], Telugu *et al*. (2019) and Chaitanya *et al*. (2021) [1] in ajwain indicating the large variation for yield and yield contributing characters

The clustering pattern exhibited that all twenty-six genotypes were grouped into four clusters (Table 2). The cluster III comprised of maximum genotypes i.e. nine genotypes (PDKV AJ 03, PDKV AJ 05, PDKV AJ 07, PDKV AJ 08, PDKV AJ 09, PDKV AJ 11, PDKV AJ 12, PDKV AJ 18 and AA-2) followed by six genotypes in cluster I (PDKV AJ 01, PDKV AJ 06, PDKV AJ 14, PDKV AJ 20, PDKV AJ 21 and PDKV AJ 22) and cluster IV (PDKV AJ 04, PDKV AJ 10, PDKV AJ 13, PDKV AJ 15, AA 19-01 and AA-93). The cluster II comprised least number of genotypes (PDKV AJ 02, PDKV AJ 16, PDKV AJ 17, PDKV AJ 19 and PKV 07). The maximum inter cluster distance of 218.72 exhibited among cluster III and cluster IV followed by cluster I and cluster IV (153.97) and cluster II and cluster III (147.01) (Table No. 3) whereas the details of cluster means for thirteen morphological traits has been given in Table No. 4

Table 1: Grouping of Ajwain genotypes in seven clusters

Cluster	No of genotypes	Details of genotypes
I	6	PDKV AJ 01, PDKV AJ 06, PDKV AJ 14, PDKV AJ 20, PDKV AJ 21 and PDKV AJ 22
II	5	PDKV AJ 02, PDKV AJ 16, PDKV AJ 17, PDKV AJ 19 and PKV 07
III	9	PDKV AJ 03, PDKV AJ 05, PDKV AJ 07, PDKV AJ 08, PDKV AJ 09, PDKV AJ 11, PDKV AJ 12, PDKV AJ 18 and AA-2
IV	6	PDKV AJ 04, PDKV AJ 10, PDKV AJ 13, PDKV AJ 15, AA 19-01 and AA-93

Table 2: Mean performance of twenty six ajwain genotypes for thirteen morphological characters

Genotypes	Days to first flowering	Days to 50% flowering	Days to maturity	Plant height at maturity (cm)	Number of primary branches per plant	Length of first internode (cm)	Number of umbels per plant	Number of umbellate per umbel	Number of seeds per umbel	Number of seeds per umbellate	Diameter of main umbel (cm)	Test weight (g)	Seed yield per plant (g)
PDKV AJ 01	75.67	83.33	132.33	80.37	9.15	1.97	70.09	15.14	244.61	19.47	3.03	0.91	4.13
PDKV AJ 02	80.00	90.00	131.67	90.73	10.85	2.57	53.19	11.73	338.67	20.61	3.27	1.02	4.17
PDKV AJ 03	74.33	88.33	130.33	89.40	8.78	2.50	60.78	13.42	225.50	19.14	4.10	1.05	3.02
PDKV AJ 04	91.67	91.33	131.67	88.40	9.99	1.97	62.66	15.93	424.96	19.77	3.17	0.56	6.78
PDKV AJ 05	64.67	82.00	132.67	80.10	10.71	2.57	59.13	14.75	185.45	15.89	4.03	0.73	3.13
PDKV AJ 06	77.33	92.00	144.67	80.80	10.94	2.07	101.67	14.59	227.62	18.48	4.00	0.56	6.87
PDKV AJ 07	90.00	96.33	144.33	75.57	8.60	2.13	81.27	10.55	147.51	16.05	3.37	0.74	4.23
PDKV AJ 08	64.67	83.00	141.33	81.43	8.42	2.12	89.54	9.35	215.78	18.62	3.20	0.96	3.03
PDKV AJ 09	61.67	90.00	133.33	81.03	10.36	2.03	59.21	9.65	190.43	15.01	3.33	1.42	6.51
PDKV AJ 10	71.67	92.33	135.67	86.77	8.89	2.27	114.47	11.50	405.07	21.85	3.50	1.06	8.16
PDKV AJ 11	91.67	107.33	132.67	103.67	9.54	2.53	79.23	13.69	194.05	12.79	3.10	1.26	8.29
PDKV AJ 12	84.67	102.33	132.33	77.40	9.02	3.03	30.24	9.31	149.59	21.54	4.10	0.89	6.32
PDKV AJ 13	78.67	93.67	132.33	83.93	9.13	2.37	71.67	14.17	394.98	14.75	4.00	1.03	4.63
PDKV AJ 14	76.67	89.67	129.67	86.57	8.70	2.50	91.91	9.71	282.91	13.56	3.03	0.53	4.73
PDKV AJ 15	85.00	98.67	135.33	94.27	11.60	2.60	101.51	13.43	388.49	11.54	3.07	0.54	5.63

PDKV AJ 16	74.67	89.33	133.33	85.63	13.19	2.03	115.07	13.15	359.55	11.66	4.20	0.64	7.84
PDKV AJ 17	75.33	87.33	132.33	94.47	10.83	2.23	95.44	13.28	335.35	22.28	3.80	0.58	3.45
PDKV AJ 18	71.33	91.00	131.67	104.43	10.57	2.10	70.71	15.30	188.97	17.56	4.03	0.64	5.33
PDKV AJ 19	68.33	84.00	130.33	112.33	9.19	3.17	111.46	16.46	302.10	20.90	3.43	0.53	4.27
PDKV AJ 20	87.33	96.33	131.67	99.20	11.74	2.27	106.04	13.33	235.37	11.33	3.67	0.52	6.49
PDKV AJ 21	63.00	86.00	132.67	118.33	12.43	1.77	118.27	14.89	252.04	19.20	3.70	0.62	4.12
PDKV AJ 22	92.33	110.67	144.67	107.07	10.74	1.87	95.61	13.13	282.87	19.43	3.17	0.78	5.08
AA-19-01	78.00	90.00	144.33	100.37	10.03	2.20	87.44	15.80	414.88	19.55	4.23	0.86	6.18
AA- 2	88.00	106.00	141.33	102.77	11.15	2.40	76.07	12.52	217.97	17.31	3.93	0.67	5.08
AA -93	65.33	85.33	133.33	113.33	11.61	2.50	101.93	16.27	419.70	15.94	3.67	0.68	4.44
PKV- 07	71.33	88.67	135.67	115.50	11.06	3.38	119.24	15.12	331.88	16.25	3.93	0.68	5.10
General Mean	77.05	92.11	135.46	93.61	10.27	2.35	85.53	13.31	282.93	17.32	3.61	0.79	5.26
S.E.(m)±	1.54	2.05	1.61	4.30	0.58	0.24	2.94	0.57	19.27	1.07	0.16	0.02	0.22
C.D. 5%	4.37	5.83	4.58	12.23	1.65	0.68	8.37	1.64	54.74	3.06	0.46	0.07	0.63

Table 3: Intra and Inter cluster distances for twenty six Ajwain genotypes

Clusters	I	II	III	IV
I	0.00	79.80	70.73	153.97
II		0.00	147.01	75.53
III			0.00	218.72
IV				0.00

Table 4: Cluster Means for thirteen morphological traits

Character	Cluster Means			
	Cluster I	Cluster II	Cluster III	Cluster IV
Days to first flowering	78.72	73.93	76.78	78.39
Days to 50% flowering	93.00	87.87	94.04	91.89
Days to maturity	135.95	132.67	135.55	135.44
Plant height at maturity (cm)	95.39	99.73	88.42	94.51
Number of primary branches per plant	10.62	11.02	9.68	10.21
Length of first internode (cm)	2.08	2.68	2.38	2.32
Number of umbels per plant	97.27	98.88	67.35	89.95
Number of umbellate per umbel	13.47	13.95	12.06	14.52
Number of seeds per umbel	254.24	333.51	190.58	408.01
Number of seeds per umbellate	16.91	18.34	17.10	17.23
Diameter of main umbel (cm)	3.43	3.73	3.69	3.61
Test weight (g)	0.65	0.69	0.93	0.79
Seed yield per plant (g)	5.24	4.97	4.99	5.97

The present study revealed that the phenotypic coefficient of variation was higher than the corresponding genotypic coefficient of variation for all the traits, which might be due to interaction of genotype with the environment to some degree or other explaining environmental factor influencing the expression of these characters (Table 5). The highest genotypic and phenotypic coefficient of variation was observed for number of seed per umbel (33.05 per cent) followed by test weight (31.08 per cent), seed yield per plant (29.86 per cent), number of umbel per plant (27.58 per cent), length of first internode (22.08 per cent) and number of seeds per umbellate (20.94 per cent). The high values of GCV suggested role of genetic component of genotypes for variability among them and the responsiveness of the attributes for making further improvement by selection. However, days to first flowering (12.64 per cent), diameter of main umbel (13.05 per cent), number of primary branches per plant (14.77 per cent), plant height at maturity (15.17 per cent) and number of umbellate per umbel (17.66 per cent) exhibited the moderate phenotypic coefficient of variation showed moderate value for genotypic coefficient of variation, indicating the potential of heterosis breeding for their amelioration. The estimate of genetic advance as percent of mean were observed significantly higher for number of seeds per umbel (168.10 per cent), number of umbels per plant (46.32 per cent), days to first flowering (29.42 per cent) and plant height at maturity (21.18 per cent), similar kind of observations were reported by Krishnamoorthy and Madalgiri (2002) [8], Dashora and Shastry (2011) [2], Ghanshyam *et al.* (2014) [5], Meena *et al.* (2014) [13, 14] and Rawat *et al.* (2020) [18].

Table 5: Estimates of genetic parameters for the thirteen morphological characters in ajwain

Characters	Range	Mean	GCV (%)	PCV (%)	h^2 (%)	GA	GAM (%)
Days to first flowering	61.67-92.33	77.05	12.16	12.64	92.50	29.42	24.09
Days to 50 % flowering	82.00-110.66	92.12	7.94	8.83	80.87	19.16	14.71
Days to maturity	129.67-144.67	135.46	3.44	4.01	73.51	8.23	6.07
Plant height at maturity (cm)	75.57-118.33	93.61	12.90	15.17	72.41	21.18	22.63
No. of primary branches per plant	8.41-13.19	10.27	11.04	14.77	55.86	1.74	17.00
Length of first internode (cm)	1.77-3.38	2.35	13.08	22.08	35.08	0.37	15.96

No. of umbels per plant	30.23-119.24	85.53	26.93	27.58	95.32	46.32	54.16
No. of umbellate per umbel	9.30-16.45	13.31	15.98	17.66	81.88	3.96	29.79
No. of seeds per umbel	147.50-424.96	282.93	30.87	33.05	87.26	168.10	59.41
No. of seeds per umbellate	11.33-22.28	17.32	17.95	20.94	73.49	5.49	31.71
Diameter of main umbel (cm)	3.03-4.23	3.61	10.39	13.05	63.48	0.61	17.06
Test weight (g)	0.52-1.42	0.78	30.59	31.08	96.86	0.49	62.02
Seed yield per plant (g)	3.02-8.29	5.26	28.93	29.86	93.88	3.04	57.75

The correlation coefficient analysis (Table 6) exhibited that seed yield per plant positively significantly correlated with days to 50 per cent flowering (r=0.49**) followed by days to first flowering (r=0.36**), number of primary branches (r=0.23*) whereas, positive non-significant correlation coefficient with number of seeds per umbel (r=0.18), number of umbels (r=0.16) and test weight (r=0.15). Moreover, the character seed yield per plant is statistically significant and negatively correlated with number of seeds per umbellate (r=-0.30**) these findings resembles to the reports of Garg *et al.* (2003) [4] in fennel for plant height, in coriander, Sharma *et al.* (2015) [19], and Shivaprasad *et al.* (2017) [20], Kumar *et al.* (2017) [9] in fennel, Yadav *et al.* (2018) [27] and Rawat *et al.* (2020) [18]. The characters like days to first flowering, days to 50 per cent flowering and days to maturity also showed positive and significant association with seed yield per plant. But besides having similar association with seed yield per plant it suggested that these characters are not real yield contributing characters.

Table 6: Correlation coefficients for thirteen morphological traits in ajwain

Characters	Days to first flowering	Days to 50% flowering	Days to maturity	Plant height at maturity (cm)	Number of primary branches per plant	Length of first internode (cm)	Number of umbels per plant	Number of umbellate per umbel	Number of seeds per umbel	Number of seeds per umbellate	Diameter of main umbel (cm)	Test weight (g)	Seed yield per plant (g)
Days to first flowering	1.00	0.84**	0.40**	-0.09	-0.09	-0.07	-0.20	-0.09	-0.01	-0.14	-0.25*	-0.12	0.36**
Days to 50 % flowering		1.00	0.46**	0.06	0.04	0.31**	-0.15	-0.27*	-0.20	-0.17	-0.15	0.12	0.49**
Days to maturity			1.00	-0.07	0.12	-0.49**	0.25*	-0.16	-0.27*	-0.11	-0.01	-0.21	0.08
Plant height at maturity (cm)				1.00	0.54**	0.27*	0.55**	0.62**	0.27*	0.03	0.03	-0.32**	-0.03
No. of primary branches per plant					1.00	-0.24*	0.47**	0.44**	0.27*	-0.40**	0.32**	-0.47**	0.23*
Length of first internode (cm)						1.00	-0.06	0.01	0.04	0.01	0.22	-0.07	-0.11
No. of umbels per plant							1.00	0.31**	0.40**	-0.21	-0.03	-0.46**	0.16
No. of umbellate per umbel								1.00	0.44**	0.08	0.29**	-0.39**	-0.04
No. of seeds per umbel									1.00	0.05	-0.02	-0.19	0.18
No. of seeds per umbellate										1.00	0.09	0.07	-0.30**
Diameter of main umbel (cm)											1.00	-0.12	0.02
Test weight (g)												1.00	0.15
Seed yield per plant (g)													1.00

Conclusion

The experiment for analyzing genetic divergence, genetic variability and correlation revealed that the twenty-six ajwian genotypes have a diverse genetic base and grouped in four divergent clusters indicated that there is no any relationship among geographical diversity and genetic diversity. The genotypes PDKV AJ 11, PDKV AJ 10, PDKV AJ 14, PDKV AJ 19 and PDKV AJ 03 found potent genotypes and can be exploited in future improvement ventures in Ajwain crop. The traits exhibiting positive relationship with seed yield per plant may be used to decide the selection criteria for trait specific hybridization program.

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