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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(4): 427-430

www.thepharmajournal.com
Received: 09-02-2023
Accepted: 12-03-2023

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Diversity analysis in ajwain (*Trachyspermum ammi* L.)

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DOI: https://doi.org/10.22271/tpi.2023.v12.i4e.19640

Abstract
Agronomy instruction farm, Sardarkrushinagar Dantiwada Agricultural University, Dantiwada, evaluated diversity studies for forty genotypes of ajwain during rabi 2019–20 using a randomised block design (RBD) with three replications. Nine clusters were formed from the genetic divergence of the forty genotypes studied for seed yield. With twenty-one genotypes, cluster I had the most. This was followed by cluster III, which had nine, cluster VII, which had four, and clusters II, IV, V, VI, VII, VIII, and IX, which each had one genotype. The 40 genotypes under investigation showed signs of diversity. Clusters VII and III had the greatest intercluster distance (D^2=897.53), which was followed by clusters V and III (D^2=768.35). The traits, including seed yield per plant, test weight, biological yield per plant, harvest index, number of branches per plant, volatile oil, number of umbels per plant, and days to flowering, had the greatest impact on the selection of parents with different genetic backgrounds.

Keywords: Ajwain, genetic divergence, genotypes, clusters

Introduction
Ajwain (*Trachyspermum ammi* L.) diploid chromosome number 18, family Apiaceae and center of origin Egypt. It is an aromatic, annual, profuse, and herbaceous plant. The plant is soft fine hair, feather-like leaves, branched leafy stems, and terminal and compound flowers. Fruits are cremocarp, ovoid, and small 2-3 mm grayish brown compressed mericarps [Malhotra and Vijay, 2004] [1]. Since the flowers are protandrous, insects are used for cross-pollination. It is particularly useful as a remedy for aphrodisiac, stomach ache, and digestive system-related issues. Additionally, it is utilised to treat cholera, diarrhoea, stomach, and urinary issues. Volatile oil, which has a colour between yellow-brown and 2 to 4%, is found in seeds [Bairwa *et al*, 2012] [2]. Bishop's weed, carum, and other English names for ajwain (*Trachyspermum ammi* L.) are also used to refer to it. It is grown primarily for its seed, herb, and volatile oil. It is grown in India, Afghanistan, Iraq, and Iran. It is grown in Rajasthan, Gujarat, Madhya Pradesh, Bihar, Punjab, Andhra Pradesh, and Telangana in India. In 2019–20, 37810 hectares of land produced 27920 MT of ajwain [Anonymous. 2019] [3]. It is grown in the Gujarati districts of Jamnagar, Banaskantha, Mehsana, Amreli, Patan, and Ahmedabad over an area of 6075 ha, producing 5790 MT. 2019-20 [3]. Geographical regions had little influence on the genetic diversity since genotypes from the same area were scattered across multiple clusters, while those from other areas were grouped together in a single cluster. Therefore, rather than relying solely on geographic diversity, a plant breeder must assess the genetic diversity of his material. Mahalanobis's D^2-statistic was used in Rao's [1952] [4] description of the multivariate study of genetic divergence.

Material and Methods
Ajwain was used as the experimental plant, and there were 40 different genotypes produced using a randomised block design (RBD) with three replications. The experimental material was planted in the ground at the Agronomy Instruction Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, during the rabi season of the 2019–20 academic year. With a 45 cm gap between each pair of rows and 10 cm between plants, two rows of each genotype were sown in a single row plot of 4.0 m in length. Each replication's plots received a random assignment of genotypes. For the effective raising of the crop, all advised agronomic procedures as well as required plant protection measures were timely implemented. These five randomly chosen plants were observed for the following characteristics: days to flowering, days to maturity, plant height (cm), number of branches per plant, number of umbels per plant, number of umbelletes per umbel, number of seeds per umbel, seed yield per plant (g),

biological yield per plant (g), harvest index (%), test weight (g), and volatile oil (%). D2-statistics created using Tocher's approach and the methods of Mahalanobis and Tocher, as explained by Rao [1952] [4].

Results and Discussion

The generalised distance (D^2) between two entries varied from 32.04 to 897.53 according to D^2 statistics calculated on forty ajwain genotypes for twelve characters, indicating that variety is present in the genotype under study. Nine groups were created from 40 ajwain genotypes based on D^2-values. With twenty-one genotypes, cluster I had the most, followed by cluster III with nine, cluster VII with four, and clusters II, IV, V, VI, VII, VIII, and IX with one genotype apiece. This demonstrated that diversity was present among the 40 genotypes examined. All feasible pairs of nine clusters were examined, and the intra- and inter-cluster distance D^2 was calculated, reported, and shown in (Table 2). (Figure 1).

The clustering pattern revealed that genotypes from different sources were combined into one group, and that genotypes from the same source formed different clusters, indicating that there was no correlation between geographic location and genetic divergence. Cluster VII and cluster III had the greatest intercluster distance (D^2=897.53), followed by cluster V and cluster III (D^2=768.35), cluster VI and cluster III (D^2=650.44), cluster IV and cluster III (D^2=581.82), cluster III and II (D^2=499.26), and cluster VII and cluster III (D^2=442.68). Clusters IV and II had the smallest intercluster distance (D^2=32.04). In the current study, cluster I (D^2=104.11) and cluster III (D^2=98.22) had the largest intra-cluster distances. The intra cluster distances between II, IV, V, VI, VIII, and IX were the smallest (D^2=0.00). Multi-genotypic clusters exhibit considerable variance for a number of traits. However, the trait with the greatest impact on genetic divergence was found to be Seed yield per plant (23%) followed by test weight (15.84%), biological yield per plant (15.64%), harvest index (12.65%), number of branches per plant (10.9%), volatile oil (9.05%), number of umbels per plant (7.4%), and days to flowering (3%) were the significant traits that contributed to overall genetic divergence. These eight crucial features contributed significantly to the observed diversity of 97.48%. Plant breeders could thus produce variety in ajwain by selecting for divergent parents based on these eight traits. The previous findings were published by [Awas *et al.* 2017, Gauhar *et al.* 2018, Nagar *et al* 2019, Singh *et al.* 2017]. contributed little (less than 3%), including the number of seeds per umbel (2%), plant height (0.26%), number of umbelletes per umbel (0.13%), and days to maturity (0.13%). A high degree of consistency and moderate to low heritability of these traits may also be implied by the low variety for these traits in such a broad set of genotypes. (Table 3 and Figure 2). The days to flowering (78.67), days to maturity (141), plant height (72.87), number of branches per plant (7.07), number of umbels per plant (100.87), number of umbelletes per umbel (16.2), number of seeds per umbel (352.73), biological yield per plant (16.39), harvest index (35.42), test weight (1.4), and volatile oil (5.22) were the component traits that contributed to the highest cluster mean for seed yield per plant (5.8) (Table 4). It is a well-known fact that the more the genetic diversity of the parents utilised in a hybridization programme, the higher the likelihood of producing high heterotic hybrids and a wide range of variability in segregating generations. Additionally, it has been noted that the majority of productive hybrids may be descended from parents who had great genetic variety and yielded high yields. It is therefore advised to attempt the cross between the genotypes present in clusters VII and III based on the highest genetic distance as this could increase genetic variety and boost ajwain yield.

Table 1: Distribution of genotypes evaluated for seed yield into different

Cluster	No. of genotypes	Name of genotypes
I	21	NDAJ-10, NDAJ-11, NDAJ 14, JA 18-04, NS 1, JA 2013-4, JA 18 -03, NDAJ 1, JA 18-02, JA 18-08, JA 16-06, JA 17-02, JA 18-06, JA 07-01, JA 16-01, LS 14-3, NDAJ 7, JA-01, JA 219, GA 2, JA -187
II	1	GA 1
III	9	JA 218, MLT 60, LS 14-08, JA 17-01, JA 07-06, AA-06, AA-73, HAJ-07, AA-02
IV	1	JA 111
V	1	JA 17-06
VI	1	AA-01
VII	4	JA 18-05, NDAJ 6, JA 18-07, JA 18-01
VIII	1	JA-190
IX	1	HAJ-18

Table 2: Average intra and inter cluster D^2 value

Cluster	I	II	III	IV	V	VI	VII	VIII	IX
I	104.11	157.84	286.23	169.62	228.12	183.13	304.13	160.41	159.3
II		0	499.26	32.04	101.21	155.91	242.21	406.75	102.46
III			98.22	581.82	768.35	650.44	897.53	241.06	431.69
IV				0	41.29	91.83	175.06	396.02	144.12
V					0	62.48	78.23	442.68	191.4
VI						0	91.21	261.15	253.85
VII							79.96	437.12	282.07
VIII								0	364.04
IX									0

Note: D^2 values is mention above table

Table 3: Contribution of various traits towards total genetic divergence

Sr. No	Characters	Time ranked first	Contribution (%)
1.	Days to flowering	23	3
2.	Days to maturity	1	0.13
3.	Plant height	2	0.26
4.	Number of branches per plant	84	10.9
5.	Number of umbels per plant	57	7.4
6.	Number of umbelletess per umbel	1	0.13
7.	Number of seed per umbel	15	2
8.	Seed yield per plant	177	23
9.	Biological yield per plant	120	15.64
10.	Harvest index	97	12.65
11.	Test weight	122	15.84
12.	Volatile oil	70	9.05

Table 4: Cluster mean for 12 different characters

Cluster	DF	DM	PH	NOB	UPP	UPU	SPU	SPP	BY	HI	TW	VO
I	81.94	145.6	80.46	9.6	82.99	13.45	274.34	4.92	18.54	26.58	1.48	4.73
II	72	135	87.2	7.13	80.4	10.67	248.88	5.1	19.45	26.25	1.35	5.21
III	79.81	141.85	80.73	9.99	89.26	14.12	315.38	5.3	19.01	27.84	1.9	5.16
IV	83.67	144.67	91.07	7.8	67.73	11.07	266.93	5.19	17.94	28.95	1.28	4.81
V	82.33	146	87.67	8.73	68.27	14.6	276.27	5.23	18.94	27.7	1.14	4.46
VI	65.33	129	77.47	9.07	64.07	9	198.07	3.66	14.95	24.49	1.1	4.02
VII	82.08	144.17	79.53	10.45	84.22	13.47	273.33	4.74	18.7	25.53	1.06	4.49
VIII	74.67	138	73.27	12.73	83.4	10.8	205.16	4.5	17.76	25.32	1.53	4.29
IX	78.67	141	72.87	7.07	100.87	16.2	352.73	5.8	16.39	35.42	1.4	5.22

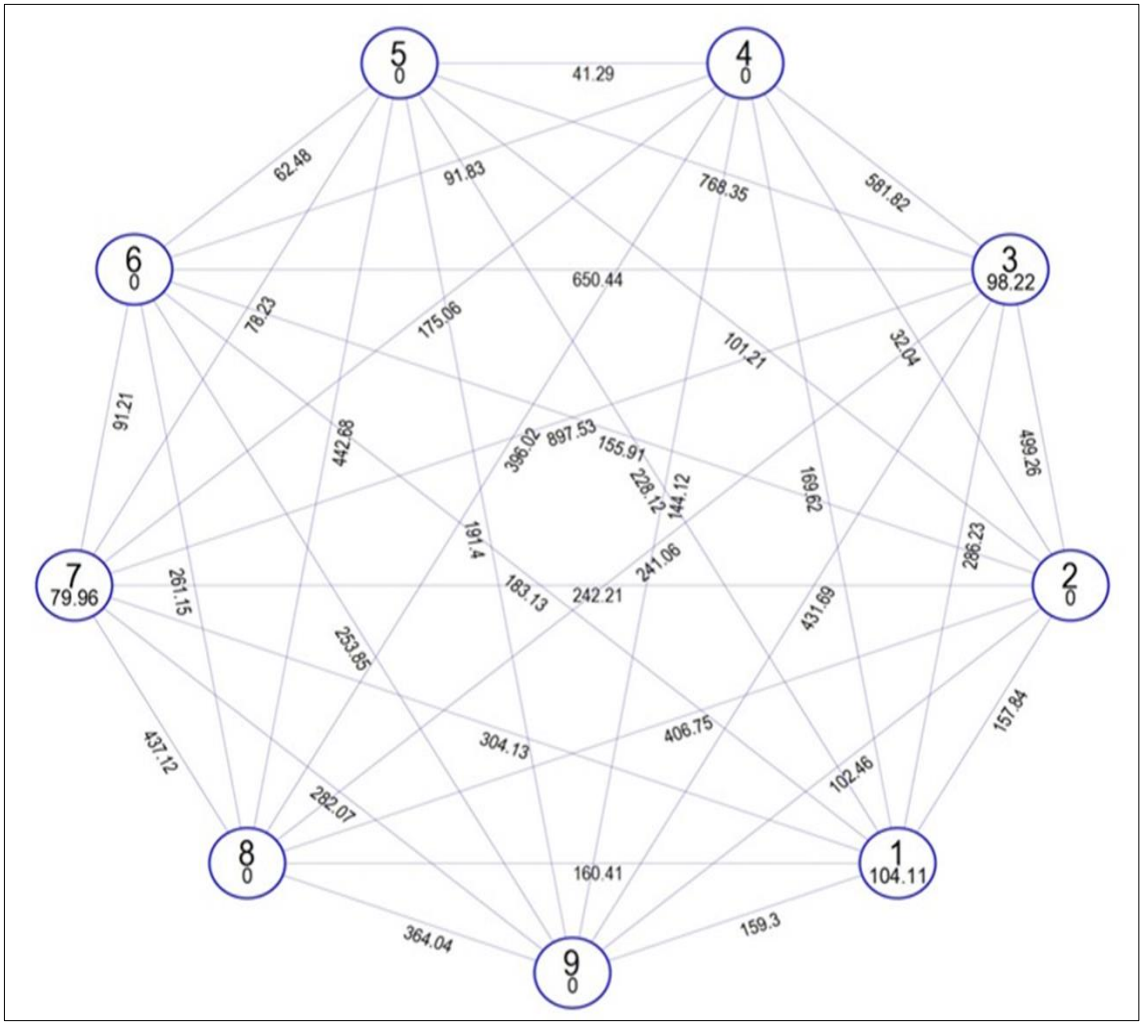

Fig 1: Diagrammatic representation of cluster diagram

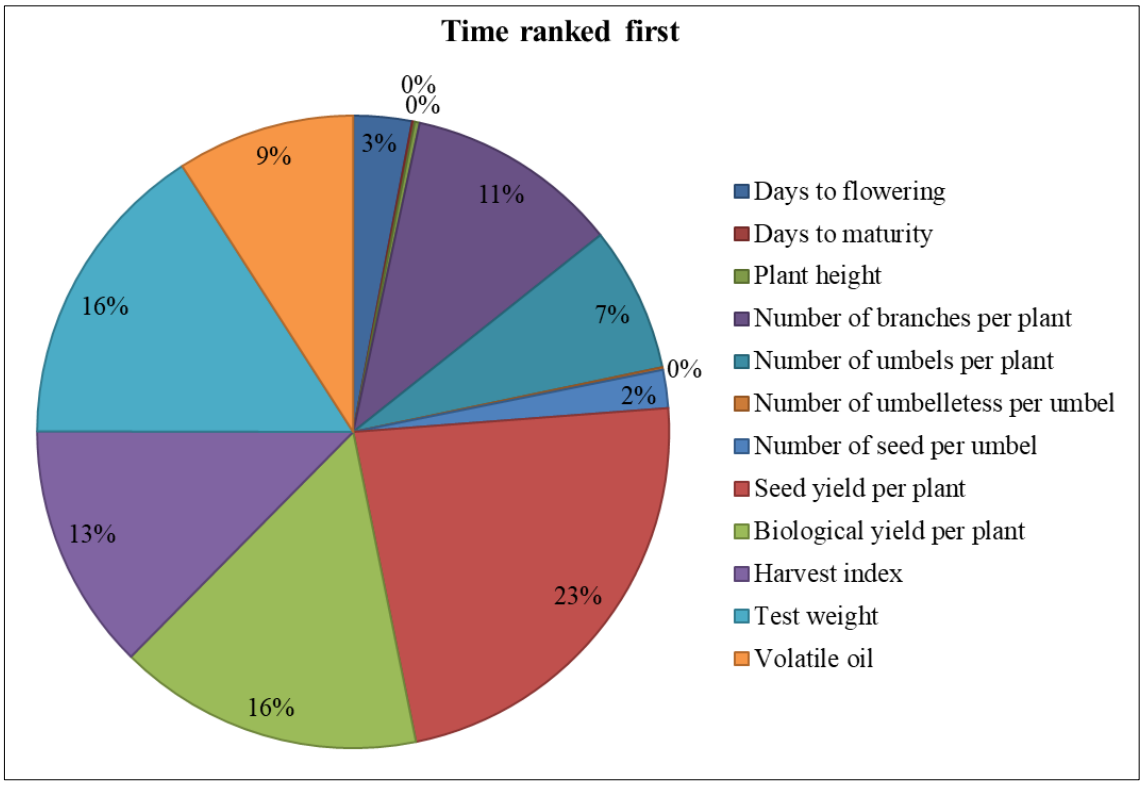

Fig 2: Contribution of various traits toward total genetic divergence

Conclusion

Among the forty genotypes of ajwain that were divided into nine clusters, D^2 analysis revealed more genetic diversity. Between clusters VII and III, where the intercluster distance was at its greatest (D^2=897.53), was followed by clusters V and III, where it was at its smallest (D^2=768.55). Cluster IV and II were found to have the smallest intercluster distance (D^2=32.04). Due to the distribution of genotypes from the same location into distinct clusters and those from different areas into a single cluster, genetic diversity was not dependent on geographic regions. Consequently, a plant breeder must assess the genetic diversity of his material rather than relying solely on their geographic diversity. The characteristics that contributed the most to overall genetic divergence were seed yield per plant, test weight, biological yield per plant, harvest index, number of branches per plant, volatile oil, number of umbels per plant, and days to blooming. Future exploitation of transgressive segregants in ajwain would benefit from selection for varied parents based on these traits. The clustering pattern might be used to choose the parents for a cross and choose the best cross combinations that could produce the greatest diversity for different attributes.

Acknowledgement

For their assistance in performing the research, the farm manager of the agronomy instructional farm and the research scientist at SDAU's Jagudan campus' seed spices research station are to be thanked. They also gave me permission to utilise their lab for my research's biochemical analysis.

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