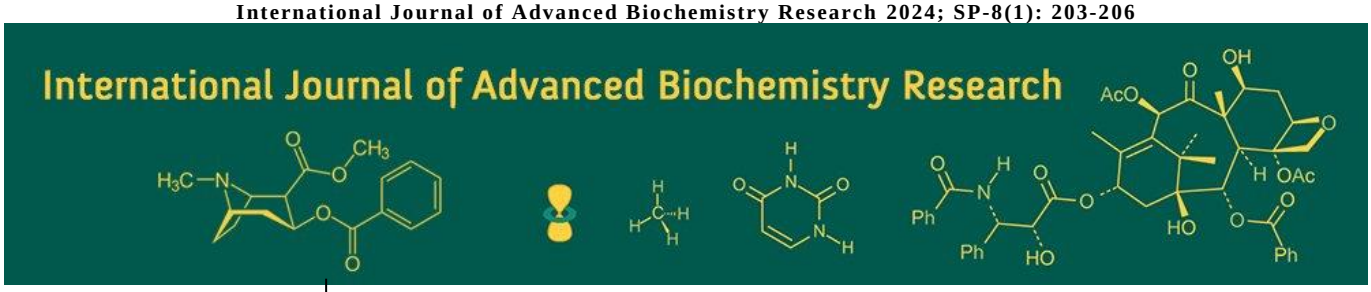

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Unveiling the Essence of Ajwain: A comprehensive exploration through principal component analysis

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Abstract
Forty Ajwain genotypes were evaluated during Rabi 2019–20 at the Agronomy Instructional Farm of the Sardar Krushinagar Dantiwada Agricultural University in Dantiwada. Every attribute has a substantial impact on the mean sum of squares. In this work, the complexity of the dataset was reduced to a simplified structure by using Principal Component Analysis (PCA) to examine the subtleties of twelve important features in ajwain genotypes. Twelve components were found through analysis; of these, the first five (PC1 through PC5) accounted for more than 87.47% of the overall variability seen in the qualities under investigation. The most variable plant, PC1, had the largest variance (45.2%), with attributes including plant height, number of umbels per plant, and seed output among others. The ensuing PCs also showed strong correlations with certain characteristics, offering a thorough comprehension of their connections respectively. Highlighting unique trait profiles were the primary scores for each genotype in the five components. Several variables showed higher values for HAJ-07 and AA-02 genotypes, which were prominent in PC1. These results confirm previous studies and emphasise the study's practical relevance even more. The genotypes HAJ-07 and AA-02 were chosen based on the highest PC scores in PC1 and PC2, which emphasises the study's practical applications even more. These findings provide important new understandings of the genetic diversity and phenotypic connections among genotypes of Ajwain, laying the groundwork for further breeding and development initiatives.

Keywords: PCA, Ajwain Genotypes, Principal Scores and Eigenvalues

Introduction
"Exploring the botanical intricacies of Ajwain (*Trachyspermum ammi* L.), a member of the Apiaceae family with a diploid chromosome number of 18, reveals its annual, aromatic, and herbaceous nature. Originating in Egypt, this profusely branched plant, known as bishop's weed or Carum, captivates with its feather-like leaves and small ovoid fruits. Noteworthy for its medicinal properties, Ajwain addresses various health concerns, as documented by Bairwa *et al*. (2012) [2]. The seeds, containing 2 to 4 percent volatile oil, showcase a yellow-brownish hue. Cultivated in Iraq, Iran, Afghanistan, and India, with notable growth in Rajasthan, Gujarat, Madhya Pradesh, Bihar, Punjab, Andhra Pradesh, and Telangana. This captivating journey into Ajwain's realm intertwines ancient wisdom and contemporary cultivation practices, offering a comprehensive perspective (Malhotra and Vijay, 2004) [7]. Join us in unraveling the secrets of Ajwain, where its rich legacy meets modern scientific understanding."

Materials and Methods
The experimental setup involved cultivating 40 Ajwain genotypes in a randomized block design (RBD) with three replications. The planting occurred during the rabi season in 2019-20 at the Agronomy Instruction Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. Each genotype was meticulously sown in a single-row plot, spanning 4.0 m in length, with a spacing of 45 cm between rows and 10 cm between plants. The genotypes were randomly allocated to the plots within each replication. Adhering to recommended agronomic practices and implementing essential plant protection measures in a timely manner ensured the successful cultivation of the crop. Observations were systematically recorded for key traits, including days to flowering, days to maturity, plant height (cm), number of branches per plant, number of umbels per plant, number of Umbellets 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 (%). The assessment involved meticulous recording from five randomly selected plants in each line across all replications, ensuring a thorough evaluation of the diverse traits exhibited by the Ajwain genotypes under scrutiny. PCA was described by Karl pearson (1901) [9]. PCA was carried out using the statistical program Opstate.

Results and Discussion

Principal component analysis reduces the complexity of a data set into a simplified structure. In the present study PCA was conducted on twelve characters of ajwain genotypes. The PCA analysis have extracted twelve components from the total traits studied. PCA for the first five principle component are listed in (table 1, Fig 1). Only five principal component PC1 to PC5 out of the twelve components exhibit more than 87.47% variability among the traits studied. The highest variation was recorded by the first PC1 (45.2%) followed by PC2 (16.1%), third component PC3 (12.3%), fourth component PC4 (7.3%) and fifth component PC5 (6.6%). The total variation of the five principal component was accounted to be 87.47%. Related conclusions were concluded by Akbari *et al.,* (2022) [1] and Elbaz *et al.,* (2022) [4].

First principal component which showed the highest variability (45.2%) consisted of high positive component was related with Plant height (cm), 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), Volatile oil (%). In second PC Positive component was related with traits such as Volatile oil (%). In third PC positive component was associated along with traits such as Number of branches per plant and Biological yield per plant (g). In fourth PC the trait Plant height (cm) and Volatile oil (%) was more related. The fifth principal component was more related to Number of branches per plant and Test weight (g) (Table 2 and Fig 2). Similar results were reported by Dalkani *et al.,* (2012) [3], Faravani *et al.,* (2018) [5] and Akbari *et al.,* (2022) [1].

The principal scores for all the twelve traits of the 40 genotypes were divided in the five principal components (Table 3 and Fig 2). High values for the traits in a genotype can be indicated using the principal score scored by that genotype in a particular component. In the first principal component HAJ-07 (2.25) has the highest score followed by AA-02 (1.90), JA 17-02 (1.53) and JA 16-06 (1.40) indicating that they have high value for Plant height (cm), 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), Volatile oil (%). In the second principal component NDAJ-11 (1.87) has the highest score followed by AA-01 (1.58) and JA 07-06 (1.44) indicating that they have high value for Volatile oil (%). In third component NDAJ 6, JA 18-05 and JA 17-02 indicating that they have high value for Number of branches per plant and Biological yield per plant (g). In fourth component LS 14-3, LS 14-08 and JA 07-06 indicating that they have high value for Plant height (cm) and Volatile oil (%). In fifth component JA-190, JA 17-01 and MLT 60 indicating that they have high value for Number of branches per plant and Test weight (g). Based on the top PC scores in principal component 1 and principal component 2, two genotypes HAJ-07 and AA-02 are selected. These results are in relevance with the results quoted by Kalleli *et al.,* (2019) [6], YALDIZ *et al.,* (2020) [10] and Modareskia *et al.,* (2022) [8].

Table 1: Eigenvalues of Correlation Matrix for Ajwain

Principal component	PC1	PC2	PC3	PC4	PC5
Eigen value	5.42	1.94	1.47	0.87	0.79
percentage of variance	45.19	16.15	12.26	7.28	6.60
cumulative percentage of variance	45.19	61.34	73.59	80.87	87.47

Table 2: Principal component analysis for 40 genotypes on 12 characters in Ajwain

Characters	PC1	PC2	PC3	PC4	PC5
Days to flowering	0.14	-0.66	-0.10	0.01	0.11
Days to maturity	0.09	-0.65	-0.14	0.23	0.13
Plant height (cm)	0.25	-0.06	0.23	0.50	-0.50
Number of branches per plant	0.15	0.10	0.55	0.08	0.53
Number of umbels per plant	0.38	0.04	0.11	-0.21	0.11
Number of umbelletes per umbel	0.39	-0.07	0.02	-0.29	-0.03
Number of seeds per umbel	0.39	0.08	-0.02	-0.14	-0.03
Seed yield per plant (g)	0.41	0.06	-0.04	-0.12	-0.16
Biological yield per plant (g)	0.35	-0.02	0.34	0.01	-0.15
Harvest index (%)	0.22	0.12	-0.57	-0.25	-0.10
Test weight (g)	0.24	0.15	-0.28	0.24	0.61
Volatile oil (%)	0.21	0.28	-0.28	0.64	-0.01

Table 3: PCA scores of Ajwain genotypes

Genotype	PC1	PC2	PC3	PC4	PC5
LS 14-3	0.84	-2.00	-0.25	2.56	1.01
HAJ-07	2.25	1.16	0.40	-0.88	1.18
LS 14-08	0.40	0.57	0.62	1.82	0.97
JA-01	-0.78	0.33	-0.11	-0.13	0.61
JA -187	-0.80	0.44	-0.92	-0.02	-0.27
JA-190	-0.88	0.74	1.17	-0.41	1.89
NDAJ-10	-2.18	0.67	0.22	-0.14	1.22
NDAJ-11	-1.74	1.87	0.44	-0.10	0.30
AA-73	-0.81	-0.18	-1.88	0.99	0.21
AA-06	1.23	-0.93	0.37	-0.78	0.49
AA-01	-2.10	1.58	0.85	-0.39	-0.74
AA-02	1.90	1.26	-1.58	-0.32	0.27
HAJ-18	0.85	0.85	-2.98	-2.58	-0.85
JA 16-06	1.40	-0.04	0.25	-1.66	-0.53
JA 16-01	-0.17	-0.23	-0.43	0.85	-0.21
JA 111	-0.22	-0.44	-0.63	1.06	-2.25
JA 218	-0.28	0.67	-0.73	0.76	1.00
JA 219	0.94	-1.12	0.17	-0.18	-0.69
JA 17-01	-0.57	0.73	-0.85	-0.03	1.38
JA 17-02	1.53	0.28	1.49	-0.08	0.68
JA 17-06	-0.03	-0.65	0.16	-0.06	-2.04
JA 18-01	-0.85	-0.91	0.26	-1.51	0.35
JA 18-02	-0.45	-0.97	0.08	-1.28	0.59
JA 18 -03	-0.71	-0.93	-0.30	-1.16	-0.54
JA 18-04	-0.04	-1.54	0.58	0.26	-0.01
JA 18-05	-0.32	-0.22	1.58	-0.45	-0.79
JA 18-06	-0.49	0.10	-0.42	-0.58	-0.37
JA 18-07	0.29	0.70	0.20	0.95	-1.09
JA 18-08	0.58	0.53	1.11	0.95	-0.11
MLT 60	-0.18	0.13	-0.55	-0.27	1.27
NS 1	0.26	-0.15	1.23	0.06	-0.77
NDAJ 1	-0.02	-0.67	-0.10	-0.33	-0.07
NDAJ 6	-0.35	-1.41	1.83	-1.24	-0.59
NDAJ 7	-0.80	-2.46	-1.44	0.85	0.83
NDAJ 14	-0.33	-1.17	0.48	-0.35	0.93
JA 07-01	0.91	-0.22	-0.98	0.08	0.53
JA 07-06	1.24	1.44	0.24	1.30	0.70
JA 2013-4	1.04	0.77	1.42	0.21	-0.89
GA 1	-0.38	1.18	0.07	1.11	-2.19
GA 2	-0.20	0.22	-1.06	1.12	-1.38

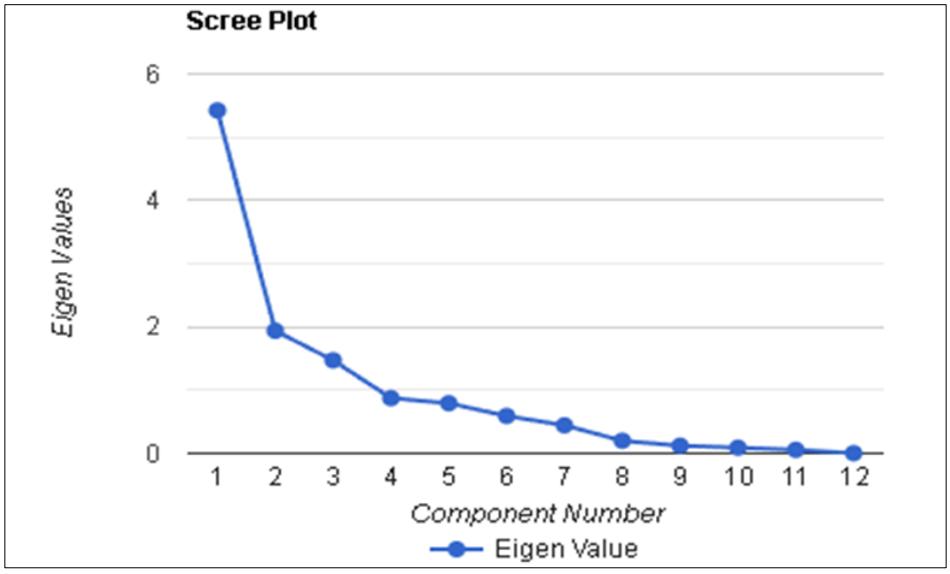

Fig 1: Screen plot for Eigen values

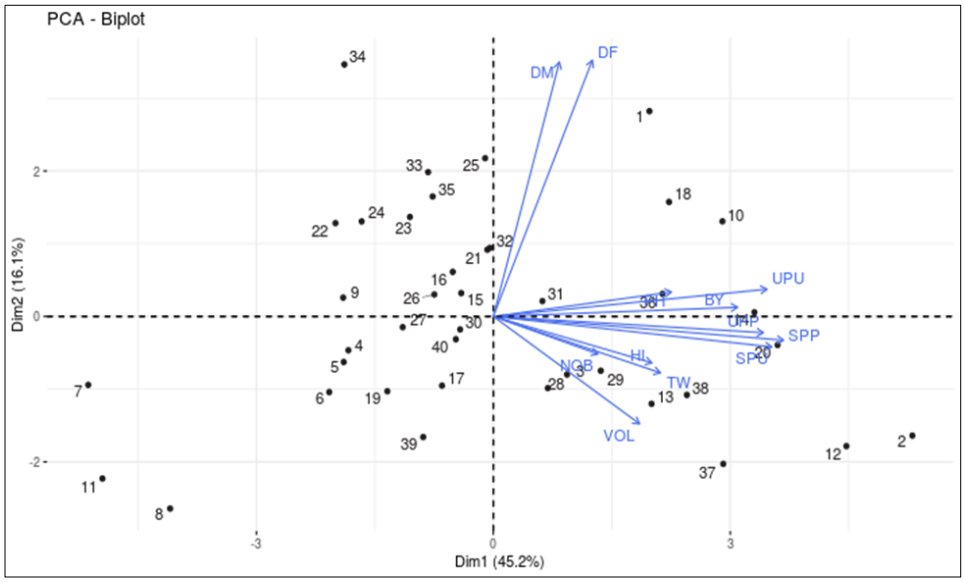

Fig 2: PCA Biplot for 40 genotypes and 12 characters

Conclusion

Ajwain genotype trait correlations were revealed using Principal Component Analysis, wherein the top five components accounted for 87.47% of the variability. AA-02 and HAJ-07 were notable genotypes that offered promise for selective breeding. These results, which are consistent with other studies, highlight the usefulness of PCA in comprehending and enhancing Ajwain cultivars.

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