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Genetic Variability, Heritability, and Genetic Advancement in Ajwain (*Trachyspermum ammi* L.)

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ABSTRACT

Sixty ajwain accessions and four check types, coupled with genetic diversity for several traits, were studied. The test weight had the highest PCV followed by the weight of grain/umbels, branches per plant, yield per plant, number of umbels per plant, plant height, and number of umblets/umbels. GCV that predict test weight are followed by the number of umbels per plant, plant height, yield per plant, weight of grain per umbel, days to 50% flowering, and days to maturity. Every character's heritability estimate ranged from high to moderate. Only the number of umbels per plant showed high heritability combined with high genetic advance, and plant height showed high heritability combined with moderate genetic advance. Other traits, measured as a percentage of the mean, showed high heritability combined with low genetic advance, highlighting the significance of these traits in yield improvement programs.

Key words: *Genetic variability, Heritability, Genetic advance, Ajwain.*

Introduction

Ajwain (*Trachyspermum ammi* L.) is one of the most significant seed crops for spices. It is a member of the Apiaceae family and has the chromosome number 2n=2x=18. It is primarily grown in India but is also widely grown in Iran, Egypt, and Afghanistan in the eastern Mediterranean region. The world's greatest producer, exporter, and consumer of ajwain seeds is India. The major importing nations are Pakistan, Saudi Arabia, the USA, the UAE, Malaysia, Nepal, Canada, and the UK. India exports ajwain to about 46 countries. In the districts of Chittorgarh, Udaipur, Rajsamand, Bhilwara, Kota, and Jhalawar in Rajasthan, it is grown over a sizeable area. The area under the ajwain crop in India for the 2017–2018 growing season is 31 mha, and the crop's production and productivity are 27 metric tonnes and 0.87 kg/ha, respectively (Anonymous, 2017-18).

It is cross-pollinated, erect, glabrous, and annual herbaceous plant, flowers are protoandrous, stem is straight, leaves are rather distant, 2-3 pinnately divided, segments linear, and ultimate segments are 1.0-2.5 cm long, flowers are in terminal or seemingly lateral pedunculate, compound umbels, white, fruits are small, avoid, muricate with distinct aromatic

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cremocarps, 2-3 mm long, with greyish-brown compressed pericarps with distinct ridges, and tubers surface, one seeded. They are branched annual plants up to 90 cm tall, cultivated almost throughout India. Ajwain owes its characteristic odor and taste to the presence of the volatile oil thymol (2-4%), which is yellowish-brown in color. The main component of ajwain oil is thymol (50%) which has a strong germicidal and anti-aggregatory effect on humans. Thymol is also used in toothpaste and perfumery. The small seeds are pale brown and have an oval shape. It has a bitter and pungent taste, with a flavor similar to anise and oregano.

Genetic variability is formed on the basis of crop improvement. The success of any breeding program depends upon the nature and magnitude of genetic variability available in the breeding material. It is essential to assess the nature and magnitude of variability, heritability, and genetic advance for various characters with respect to the germplasm available for maximizing the correlated response to selection.

Materials and Methods

The present investigation, was carried out during the Rabi season of 2017–18 at the Main Experiment Station, Narendra Nagar (Kumarganj), Ayodhya (U.P.) India. Geographically, Narendra Nagar falls under a humid sub-tropical climate and is located between 24.470 and 26.560 N latitude and 82.120 and 83.980 E longitude at an altitude of 113 m above the mean sea level in the Gangetic alluvial plains of eastern Uttar Pradesh. This design was used in this crop for two reasons: first, the number of lines to be evaluated was higher and the seed supply was less. Therefore, in this design, the evaluation of the check is first done to get an estimate of error, which is used for deriving adjusted values of accessions. The field was divided into 5 blocks; in each block, 12 genotypes and 4 checks were sown. Accessions and check varieties were sown in a plot size of 1.50×0.60 m^2 accommodating two rows 45×30 cm apart with plant-to-plant distance. The observations were recorded on different morphological characters, i.e., germination%, plant height (cm), number of branches/plant, days to 50% flowering, number of umbels/plant, number of umbellates/umbel, weight of grains/umbel (g), days to maturity, test weight (g), and seed yield/plant (g). The genotypic and phonotypic coefficients of variation were estimated as suggested by Burton (1953); heritability (h^2) in the broad sense and expected genetic advance were calculated following Johnson *et al*. (1955).

Results and Discussion

The comparison of the mean performance of genotypes revealed the existence of a very high level of variability in the germplasm collection. The genotypes NDAJ-25, NDAJ-32, NDAJ-44, NDAJ-20, and NDAJ-51 significantly out yielded all other genotypes as well as check. These are the top five performers for seed yield per plant. The genotype NDAJ-20 also possesses a high mean performance for plant germination per cent and yield/plant. In order to evaluate the germplasm collection, the mean of sixty genotypes and four checks for ten characters are presented in Table 1.

The highest range of PCV value was recorded for test weight (15.02 g), followed by weight of grain/umbel (13.477g), branches/plant (12.239%), yield/plant (9.617g), number of umbels/plant (9.044%), plant height (8.920%), and number of umblets/umbels (8.680%). The remaining characters, germination %, days to 50% flowering, and days to maturity, showed a low value for PCV. The data on PCV indicated that there is a greater scope of selection for the characters that showed a high value of PCV, and the characters that showed a low value are the least effective. The highest range of GCV value was recorded for test weight (11.277 g), followed by number of umbels/plant (8.604%), plant height (8.544%), yield/plant (8.077%), weight of grain/umbel (5.019 g), days to 50% flowering (2.885%), and days to maturity (2.779%). The remaining characters, germination %, number of branches/plants, and number of umblets/umbels, expressed a low value of GCV. The PCV was higher than its corresponding GCV for all the parameters under the present study for all the characters presented in Table 1 and 2.

The value of (h^2) ranged from 34.83 % (days to 50% flowering) to 93.19 % (test weight). The only three genotypes showed low heritability (<50%) in the case of number of umbels/plant (46.71%), plant height (44.48%), and days to 50% flowering (34.83%), while moderate heritability (50-75%) was recorded in germination % and yield/plant (50.49%), and high heritability (>75%) was observed in test weight (93.19%), number of umbellets/umbel (91.92%), weight of grains/umbel (89.64%), days to maturity (88.34%), and number of branches/plant (85.99%), High heritability coupled with high ge-

Table 1. Mean performance of sixty four genotypes for ten characters in ajwain germplasm.

Genotypes	Germination % C1	Days of 50% flowering C2	No. of Branches/ plant C3	No. of Umbels/ plant C4	No. of Umblets/ Umble C5	Wt. of grain/ Umbel (g) C6	Plant height (cm) C7	Days to maturity C8	Test weight (g) C9	Yield/ Plant (g) C10
NDAJ-1	90.75	96.65	13.39	129.41	14.58	1.44	96.61	148.85	1.37	32.05
NDAJ-2	92.75	95.65	12.79	120.61	15.68	1.49	99.61	145.85	1.30	31.12
NDAJ-3	91.75	97.65	13.39	127.01	14.98	1.65	87.61	146.85	1.19	27.92
NDAJ-4	94.75	96.65	12.39	118.71	17.18	1.69	89.61	147.85	1.29	37.97
NDAJ-5	92.75	100.65	14.79	141.51	16.58	1.19	93.21	149.85	1.13	32.30
NDAJ-6	91.75	96.65	13.79	133.61	17.58	1.29	85.41	147.85	1.14	35.90
NDAJ-7	92.75	98.65	15.79	152.61	17.78	1.24	101.01	149.85	1.24	31.10
NDAJ-8	93.75	98.65	14.39	137.81	19.18	1.49	106.41	148.85	1.28	37.62
NDAJ-9	89.75	98.65	15.79	155.41	16.98	1.54	100.01	153.85	1.40	33.08
NDAJ-10	90.75	100.65	14.79	139.11	19.08	1.42	111.41	149.85	1.28	35.02
NDAJ-11	91.75	98.65	10.79	107.61	17.78	1.38	85.41	152.85	1.24	32.31
NDAJ-12	89.75	98.65	12.99	123.61	15.98	1.28	77.01	152.85	1.27	34.47
NDAJ-13	93.50	100.65	12.17	120.41	16.81	0.96	75.84	153.85	1.25	35.40
NDAJ-14	92.50	100.65	12.57	128.11	16.21	1.15	99.24	155.85	1.29	34.41
NDAJ-15	93.50	103.65	14.57	139.41	17.41	0.93	86.24	156.85	1.32	33.08
NDAJ-16	92.50	99.65	12.37	125.31	16.41	1.05	98.99	158.85	1.39	34.05
NDAJ17	96.50	102.65	14.57	148.21	18.81	1.01	108.24	155.85	1.24	40.08
NDAJ-18	92.50	96.65	11.37	116.01	19.81	0.83	97.04	157.85	1.15	35.30
NDAJ-19	94.50	101.65	11.87	117.91	19.21	1.09	89.64	156.85	1.24	33.72
NDAJ-20	95.50	95.65	14.57	137.41	19.41	1.21	103.84	155.85	1.28	43.08
NDAJ-21	90.50	100.65	13.37	133.31	18.11	0.89	108.24	160.85	1.28	28.92
NDAJ-22	92.50	100.65	14.77	150.51	17.21	0.86	112.04	161.85	1.34	28.05
NDAJ-23	91.50	105.65	13.17	133.51	16.21	0.80	118.84	160.85	1.72	35.99
NDAJ-24	90.50	102.65	15.37	158.51	18.61	1.16	100.64	161.85	1.38	34.76
NDAJ-25	90.75	103.90	14.15	143.46	17.23	1.32	109.57	163.85	1.44	40.36
NDAJ-26	89.75	103.90	14.25	160.56	14.23	0.99	111.57	163.85	1.63	32.54
NDAJ-27	91.75	103.90	15.35	161.86	16.43	1.32	93.97	164.85	1.80	36.47
NDAJ-28	89.75	95.90	15.75	161.46	17.43	1.20	108.37	165.85	1.73	31.36
NDAJ-29	90.75	94.90	13.75	140.36	17.53	1.29	102.77	164.85	1.72	30.67
NDAJ-30	93.75	93.90	12.15	126.76	17.03	1.30	101.37	162.85	1.29	38.16
NDAJ-31	95.75	96.90	13.15	130.56	15.23	1.47	87.37	166.85	1.37	43.79
NDAJ-32	94.75	97.90	12.35	128.66	14.03	0.93	97.97	164.85	1.35	41.54
NDAJ-33	92.75	98.90	14.75	151.16	18.03	1.06	100.17	165.85	1.35	32.46
NDAJ-34	91.75	103.90	16.55	168.66	15.03	1.25	110.97	161.85	1.33	31.19
NDAJ-35	90.75	102.90	17.55	171.16	13.43	0.81	118.37	164.85	1.57	32.52
NDAJ-36	89.75	99.90	15.15	153.06	15.13	1.12	121.07	165.85	1.31	38.99
NDAJ-37	94.00	105.40	12.11	123.89	15.18	1.28	113.61	164.60	1.59	30.51
NDAJ-38	95.00	113.40	14.11	151.39	16.38	0.93	115.01	162.60	1.73	32.49
NDAJ-39	93.00	113.40	12.11	126.89	14.18	0.98	123.41	162.60	1.56	29.14
NDAJ-40	91.00	102.40	13.51	144.79	16.98	1.32	108.61	163.60	1.64	31.48
NDAJ-41	91.00	100.40	11.91	126.99	16.18	1.16	112.41	163.60	1.74	31.69
NDAJ-42	91.00	101.40	12.11	127.39	12.38	1.61	92.41	164.60	1.44	33.76
NDAJ-43	95.00	102.40	13.91	149.89	17.68	0.99	99.41	164.60	1.54	34.04
NDAJ-44	96.00	103.40	15.51	162.19	15.98	1.33	115.41	163.60	1.43	42.04
NDAJ-45	94.00	105.40	13.51	145.29	16.38	1.33	103.61	165.60	1.23	37.13
NDAJ-46	92.00	104.40	13.71	147.39	16.18	1.24	102.01	160.60	1.49	33.49
NDAJ-47	93.00	104.40	14.71	158.49	15.18	1.11	108.21	160.60	1.53	33.19
NDAJ-48	94.00	103.40	14.91	159.69	15.38	0.97	103.61	160.60	1.43	31.11
NDAJ-49	89.00	93.40	13.89	146.94	17.01	1.42	114.38	166.85	1.36	39.21
NDAJ-50	93.00	97.40	11.99	154.04	18.61	1.32	109.18	153.85	1.47	35.27

Table 1. *Continued ...*

Genotypes	Germination % C1	Days of 50% flowering C2	No. of Branches/ plant C3	No. of Umbels/ plant C4	No. of Umblets/ Umble C5	Wt. of grain/ Umbel (g) C6	Plant height (cm) C7	Days to maturity C8	Test weight (g) C9	Yield/ Plant (g) C10
NDAJ-51	90.00	103.40	10.44	144.94	16.11	1.43	105.58	170.85	2.17	41.02
NDAJ-52	91.00	106.40	13.65	140.84	20.61	1.31	98.18	150.85	1.88	31.71
NDAJ-53	89.00	100.40	12.52	139.64	20.61	1.47	108.28	167.85	1.87	34.94
NDAJ-54	93.00	96.40	13.52	129.84	19.11	1.59	104.51	165.85	2.19	38.41
NDAJ-55	90.00	98.40	10.31	132.84	20.01	1.16	105.38	167.85	2.11	32.31
NDAJ-56	91.00	99.40	11.30	137.04	17.91	1.33	108.11	165.85	1.71	33.81
NDAJ-57	92.00	100.40	10.23	122.84	20.11	1.17	107.85	169.85	1.57	33.47
NDAJ-58	91.00	97.40	12.63	128.94	20.61	1.16	108.85	160.85	2.09	34.27
NDAJ-59	90.00	98.40	13.24	139.54	18.71	1.32	104.85	161.85	2.08	32.94
NDAJ-60	91.00	100.40	14.52	146.64	19.61	1.36	107.31	166.85	2.10	39.94
AA-1	95.00	104.00	13.86	138.44	15.64	1.10	100.34	159.00	1.72	40.43
AA-2	95.40	104.40	14.04	143.90	17.36	1.27	103.92	159.80	1.54	38.72
GA-1	92.00	102.20	11.78	142.72	17.82	1.40	103.97	164.00	1.99	37.12
GA-2	92.60	103.00	11.11	139.48	18.70	1.57	104.89	169.60	2.10	37.66
Mean	92.26	100.79	13.46	139.78	17.10	1.23	102.95	160.11	1.51	34.82
Std. Dev.	1.88	3.89	1.55	14.01	1.85	0.21	9.91	6.49	0.28	3.74
Lowest	89.00	93.40	10.23	107.61	12.38	0.80	75.84	145.85	1.13	27.92
Highest	96.50	113.40	17.55	171.16	20.61	1.69	123.41	170.85	2.19	43.79

Table 2. Estimates of range, grand mean, phenotypic (PCV) and genotypic (GCV) coefficient of variation, heritability in broad sense [$h^2_{(bs)}$%], genetic advance in per cent of mean ($\overline{Ga}$%) for ten characters in Ajwain genotypes.

Character	Range		Grand Mean ($\overline{x}$)	PCV (%)	GCV (%)	ECV (%)	Heritability broad sense [h^2%]	Genetic advance	Genetic advance in per cent of mean (%)
	Min.	Max.							
Germination%	89.00000	96.50000	92.26563	1.834	-0.674	1.953	@ 13.5	-0.4701	-0.5101
Days to 50% Flowering	93.40000	113.40000	100.79063	3.547	2.885	2.063	66.18	4.8647	4.8349
No of Branches/ Plant	10.23000	17.55000	13.46672	12.239	-4.030	12.885	@110.84	-0.3696	-2.7342
No of Umbels/plant	107.61000	171.16000	139.78531	9.044	8.604	2.788	90.5	23.5530	16.8605
No. of Umblets/Umbels	12.38000	20.61000	17.10844	8.680	-2.574	9.054	@ 8.79	-0.2687	-1.5722
Weight of grain/umbel (g)	0.80000	1.69000	1.23016	13.477	5.019	12.507	13.87	0.0471	3.8510
Plant height (cm)	75.84000	123.41000	102.95297	8.920	8.544	2.563	91.74	17.3517	16.8579
Days to maturity	145.85000	170.85000	160.11563	3.275	2.779	1.733	72.01	7.7693	4.8583
Test weight (g)	1.13000	2.19000	1.51875	15.025	11.277	9.928	56.33	0.2611	17.4357
Yield/ Plant (g)	27.92000	43.79000	34.82891	9.617	8.077	5.220	70.54	4.8334	13.9752

@ = indicate broad scene heritability in negative direction

netic advance was observed for all the traits except germination percentage, days to 50% flowering, number of umbels/plant, plant height, days to maturity, and yield per plant. This indicated the possibility for selection response in the available germplasm of ajwain.

Genetic variability is the raw material for plant breeding, and heritability and genetic advance in percent of mean provide an index of transmissibility of traits, indicating the effectiveness of selection in improving genotypes. Heritability was higher for plant height, umbels per plant, days to maturity, and yield per plant, while moderate heritability was observed for test weight, days of 50% flowering, and seed yield. However, low genetic advance observed for germination %, number of branches/plant, num-

ber of umblets/plant, and days to 50% flowering. The same finding was studied by Shukla *et al*. (2003); Dalkani *et al*. (2012), Singh *et al*. (2014); Meena *et al*. (2014); Ghanshyam *et al.* (2015) and Subramaniyan *et al*. (2018).

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Conclusion

The phenotypic coefficients of variation (PCV) were higher than their corresponding genotypic coefficients of variation (GCV) for all the parameters under the present study. High heritability coupled with high genetic advance was observed for all the traits except germination percentage, days to 50% flowering, number of umbels per plant, plant height, days to maturity, and yield per plant. This indicated the possibility for selection response in the available germplasm of ajwain.

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