E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(6): 506-510
Received: 04-03-2024
Accepted: 05-04-2024

Ranjeetha R
Department of Horticulture, College of Sericulture, Chintamani, Karnataka, India

Vishnuvardhana
University of Horticultural Sciences, Udyanagiri, Bagalkot, Karnataka, India

Ramachandra RK
Horticultural Research and Extension Center, Hogalgere, Kolar, Karnataka, India

Ramegowda GK
Department of Agricultural Entomology, College of Horticulture, Yalachahalli Horticulture Farm, Mysore, Karnataka, India

Sangeetha CG
Department of Plant Pathology, College of Horticulture, UHS Campus, GKVK, Bengaluru, Karnataka, India

J Venkatesh
Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, UHS Campus, GKVK, Bengaluru, Karnataka, India

Corresponding Author:
Ranjeetha R
Department of Horticulture, College of Sericulture, Chintamani, Karnataka, India

Correlation and path coefficient analysis in yield and yield related components of Ajwain (*Trachyspermum ammi* L.) genotypes under Eastern dry zone of Karnataka

Ranjeetha R, Vishnuvardhana, Ramachandra RK, Ramegowda GK, Sangeetha CG and J Venkatesh

DOI: https://doi.org/10.33545/2618060X.2024.v7.i6g.916

Abstract
A field investigation with fourteen ajwain genotypes was conducted at the College of Horticulture, Bengaluru, India, from October 2019 to April 2020. Eleven characters such as plant height, primary & secondary branches per plant, days to 50 per cent flowering, days to maturity, umbels per plant, Umbellet per umbel, seeds per umbel, test weight, harvest index and seed yield per plant were subjected to correlation and path analysis. Significant positive genotypic and phenotypic association of plant height, primary branches per plant, umbels per plant, umbellate per umbel, seeds per umbel and harvest index with seed yield per plant was exhibited by the crop. Likewise, significant negative correlation was noticed for yield with days taken for 50 per cent flowering and number of days for maturity. Path analysis revealed that primary branches, umbels per plant, Umbellet per umbel, seeds per umbel, test weight and harvest index exhibited positive and direct effects on seed yield per plant whereas secondary branches per plant and days to maturity registered negative direct effect on seed yield per plant. From the analysis it is evident that, these traits should be selected for further crop improvement.

Keywords: Ajwain, growth and yield parameters, genotypic association, seed yield and variability

Introduction
Ajwain, from the Apiaceae family (Gersbach PV and Reddy N, 2002) [11], is medicinally important commercial seed spice. It is scientifically called as *Trachyspermum ammi* L (2n=18), having its origin in Egypt. Ajwain is called by different names in different places, and its popularly known as Carom seed, Carom Ajowan, and Bishop's weed (Chauhan *et al*., 2012) [5]. It is distributed in many parts of India, Iran, Afghanistan, etc. The crop occupies a larger area in Indian "seed spice bowl" (Lal., 2018) [15] that is, Rajasthan (15,430 ha area and 10,540 tonnes production) and Gujarat (5,320 ha and 5,050 tonnes), the states such as Telangana, Madhya Pradesh, Andhra Pradesh, Uttar Pradesh, Uttaranchal, Haryana, Punjab, Maharashtra and to small extent, Karnataka have adopted ajwain cultivation. The length of growing season of ajwain in Karnataka is short compared to that prevailing in Rajasthan (Solemani *et al*., 2011) [26]. The crop also has acquired cropping area under West Bengal and Bihar (Mohsenzadeh *et al*., 2012) [19]. Thus, ajwain is grown to an extent of 34,500 ha with 27,940 tonnes of production in India (Anon., 2018) [1]. It is a predominent export-oriented agricultural commodity, the major ajwain importing countries are Yemen, Dubai, Malaysia, Pakistan, Saudi Arabia, Indonesia, Singapore, UAE and USA (Ravindrababu *et al*., 2012) [23]. Hence, there is a necessity to increase the production of ajwain by introducing them into new and non-traditional areas.
Ajwain is an annual herb, grows erect and reaches a height of 70-90 cm (Chatterjee, A.S.C., 1995) [4]. The plant is glabrous and slightly pubescent, having striated branched leafy stems, with 2-3 pinnately divided feathery leaves. The plant bears terminally or seemingly lateral compound umbels, the white flowers are self-fertile and are cross pollinated (wind & insects). The flowers upon pollination turn pinkish and produces single seeded greyish brown seeds (Hassanshahian *et al*., 2014) [7]. The seeds are cremocarps having prominent ridges and tubular surface (Farooqi *et al*., 2005) [9].

The seeds are pungent, aromatic, thus used for culinary purpose (Muvel *et al*., 2015) [20]. The crop has immense medicinal value, hence, the seeds are used traditionally for treatment of various diseases (diarrhea, dysentery, atonic dyspepsia, cholera, abdominal tumors, galactagogue) as it possesses pharmacological properties. It acts as an antioxidant, antifungal, nematicidal, anthelmintic agent (Dubey and Kashyap., 2015) [6]. Oil also exhibits antimicrobial, anti-diuretic property and anti aggregatory effects on humans (Bairwa *et al*., 2012) [3].

The crop has larger area in Northern states and in recent times, the crop has become potentially important in the southern parts of India. The previous research papers written by us; Ranjeetha R, Vishnuvardhana, Ramegowda GK, Ramachandra RK, Sangeetha CG and Venkatesh J (2021 & 2020) on "Assessment of ajwain (*Trachyspermum ammi* L.) genotypes for reproductive and yield attributes under Eastern dry zone of Karnataka" and "Insect pest spectrum on ajwain, *Trachyspermum ammi* L. genotypes under eastern dry zone of Karnataka" depicts that the genotype GA-1 performed well under Eastern dry zone of Karnataka for reproductive and yield attributes. The mean pest population was 2.23 defoliators per plant, 4.98 per cent stem fly infestation which caused 1.73 per cent plant mortality per 3.8 m^2 plot and 61.85 aphids per 5 cm apical shoot. Aphid population was significantly least on genotype, Lam Sel-1 (43.37) and AA-2 (51.43) and was maximum on DAC-8 (71.90) which indicates scope for exploring the variability for aphid in crop improvement programme. The extended work is to reveal the correlation and path coefficient analysis in ajwain genotypes.

Materials and Methods

The investigation was undertaken during October 2019 to April 2020 at the Department of Plantation, Spices, Medicinal and Aromatic crops, College of Horticulture, University of Horticultural Sciences Campus, GKVK, Bengaluru, Karnataka, India. It is located at an elevation of 930 meters above MSL with 12°58' North latitude and 77°35' East longitude. This experimental site comes under Eastern Dry Zone of Karnataka. The experimental field was fairly levelled comprising red sandy loam soil of uniform fertility status with a pH of 6.4.

The study was conducted with 14 genotypes obtained from different institutions. The genotypes DAC-1 to DAC-8 were obtained from HRS, Devihosur, GA-1 was obtained from Gujarat Agriculture university, AA-1, AA-2 and AA-93 were from NRCSS, Ajmer, Rajasthan. Whereas, Lam Sel-1 and Lam Ajwain-2 were obtained from Lam, Guntur, Andhra Pradesh. The assessment was undertaken in a randomized complete block design with three replications. A healthy crop was raised by adopting complete package of practices. The seed were line sown at a spacing 45 cm x 20 cm in 3.78 m^2 (2.7 m x 1.4 m) plots. The five representative plants out of 42 plants in every plot were tagged to document the observations. The data recorded on growth, yield parameters and yield during the study were analyzed by Fisher's method of variance analysis with statistical design RCBD as mentioned in the previous research paper written by us; Ranjeetha R, Vishnuvardhana, Ramachandra RK, Ramegowda GK, Sangeetha CG and Venkatesh J (2021) on "Assessment of ajwain (*Trachyspermum ammi* L.) genotypes for reproductive and yield attributes under Eastern dry zone of Karnataka". Correlation and path co-efficient analysis was carried for eleven characters such as plant height, primary & secondary branches per plant, days to 50 per cent flowering, days to maturity, umbels per plant, Umbellet per umbel, seeds per umbel, test weight, harvest index and seed yield per plant in different ajwain genotypes and tested for significance as per procedures described by Panse and Sukhatme (1967) [16] and Singh and Choudary (1985) [24] by using Indostat software for the analysis.

Results and Discussion

The ajwain genotypes exhibited significant differences in reproductive, yield parameters and yield; and pest infestation confirms the presence of genetic variability owing to differences amongst them.

Genotypic and Phenotypic correlation coefficient analysis

Genotypic and phenotypic association of various characters with seed yield was determined (Table 1 & 2) to understand positive and negative link of various characters with seed yield per plant in ajwain. Plant height owned highly significant positive genotypic and phenotypic connection with harvest index (0.729 & 0.450), seed yield per plant (0.728 & 0.645), umbels per plant (0.735 & 0.687), test weight (0.733 & 0.732), seeds per umbel (0.727 & 0.649).

Primary branches possessed positive, highly significant genotypic and phenotypic association interaction with seeds per umbel (0.841 & 0.781), umbels per plant (0.806 & 0.762), harvest index (0.923 & 0.627), Umbellet per umbel (0.745 & 0.705) and per plant seed yield (0.796 & 0.755). Secondary branches held negative, highly significant interaction with plant height (-0.806 &-0.746).

Days to 50 per cent flowering possessed positive highly significant genotypic and phenotypic association with days to maturity (0.916 & 0.820). Days to maturity was positively highly significantly linked with days to 50 per cent flowering (0.916 & 0.820). It had negative connection with seed yield per plant (-0.626 &-0.557).

Seeds per umbel expressed positive highly significant genotypic and phenotypic association with umbels per plant (0.975 &0.930), seed yield per plant (0.975 & 0.918), harvest index (0.923 & 0.645), primary branches (0.841 & 0.782), Umbellet per umbel (0.824 & 0.759) and plant height (0.727 & 0.649). The test weight was positively associated highly significant with plant height (0.733 & 0.532), harvest index was positively associated with seed yield per plant (0.916 & 0.665).

Analysis of the association of several traits with yield aids in identification as well as selection of traits contributing more for yield. The association may be negative or positive with yield, it assist in finding out the magnitude of trait association. It is also very important to know the association among different traits. The correlation among traits may be a result of linkage or pleiotrophy or any other developmentally induced functional factors. The plant phenotype is the result of interaction of many factors. In the present investigation, genotypic and phenotypic association of morphological characters with yield was determined (Table 1 & 2).

Plant height, primary branches per plant, umbels per plant, umbellate per umbel, seeds per umbel and harvest index were positively significantly associated with seed yield per plant at both genotypic and phenotypic levels. A contrasting association i.e., significant negative correlation was noticed for yield with days taken for 50 per cent flowering and seed maturity. Negative link of days to maturity with seed yield per plant is due to sudden increase in the temperature which led to sucking pest (aphids) infestation on the crop during the investigation. The reports of Ranjeetha *et al*. (2020 and 2021) [21, 22] in ajwain genotypes, Ghanshyam *et al*. (2015) [10] and Faravani *et al*. (2018) [8] in ajwain genotypes/ accessions, Kassaun *et al*. (2013) [14], Jain *et al*. (2013) [13], Patahk *et al*. (2014) [17] and Meena *et*

al. (2014) [18] in coriander accessions, Singh *et al.* (2016) [25] and Gurjar *et al*. (2016) [12] in fenugreek genotypes and Bahraminejad *et al*. (2011) [2] in cumin ecotypes supports the present findings.

Path coefficient analysis

Genotypic path analysis of various characters on yield was determined (Table 3). Plant height exhibited direct and positive effect (0.985) on seed yield per plant (rG=0.728). Primary branches per plant showed direct and positive response (0.380) on seed yield per plant (rG=0.796) but secondary branches per plant showed direct and negative effect (-0.923) on seed yield per plant (rG=-0.257). Days to 50 per cent flowering expressed direct and negative effect (-0.004) on seed yield per plant (rG=-0.728). Days to maturity held direct and negative response (-0.559) on seed yield per plant (rG=-0.626). Umbels per plant, Umbellet per umbel and seeds per umbel displayed direct and positive response (0.160, 0.036 & 0.932) on seed yield per plant (rG=0.927, rG=0.760 & rG=0.975). Test weight showed direct and positive effect (0.186) on seed yield per plant (rG=0.343). Harvest index held positive direct effect (0.122) on seed yield per plant (rG=0.916).

Phenotypic path analysis of morphological characters with yield was determined (Table 4). Plant height had direct negative contribution (-0.072) on seed yield per plant (rP=0.645). Primary branches per plant expressed direct and positive contribution (0.053) on seed yield per plant (rP=0.755) but secondary branches held direct and negative effect (-0.155) on seed yield per plant (rP=-0.252). Days to 50 per cent flowering registered direct and positive effect (0.001) on seed yield per plant (rP=-0.653). Direct and negative contribution (-0.300) of days to maturity was registered on seed yield per plant (rP=-0.557). Umbels per plant contributed directly and positively (0.416) on seed yield per plant (rP=0.879). Umbellet per umbel expressed direct and positive effect (0.068) on seed yield per plant (rP=0.711). Seeds per umbel expressed direct and positive effect (0.223) on seed yield per plant (rP=0.918). Test weight exhibited direct and positive contribution (0.031) on seed yield per plant (rP=0.278).

Among eleven characters studied (Table 3 and 4), primary branches, umbels per plant, Umbellet and seeds per umbel; test weight and harvest index exhibited positive direct effects on seed yield per plant. Meanwhile, secondary branches per plant and days to maturity registered negative and direct effect on seed yield per plant. The results reported by Kassahun *et al*. (2013) [17] and Meena *et al*. (2014) [18] in coriander accessions/ genotypes, Jain *et al*. (2013) [13], Patahk *et al*. (2014) [17], Gurjar *et al.* (2016) [12] and Singh *et al*. (2016) [25] in fenugreek genotypes provides support to present findings.

Table 1: Genotypic correlation coefficient among yield and yield attributing characters in ajwain genotypes

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
X1	1	0.391*	-0.806**	-0.228	-0.096	0.735**	0.670**	0.727**	0.733**	0.729**	0.728**
X2		1	0.123	-0.634**	-0.423*	0.806**	0.745**	0.841**	-0.193	0.923**	0.796**
X3			1	-0.007	-0.132	-0.245	-0.243	-0.217	-0.766**	-0.021	-0.257
X4				1	0.916**	-0.496**	-0.409*	-0.600**	-0.064	-0.632**	-0.728**
X5					1	-0.320*	-0.179	-0.467*	-0.159	-0.576**	-0.626**
X6						1	0.799**	0.975**	0.280	0.735**	0.927**
X7							1	0.824**	0.348*	0.852**	0.760**
X8								1	0.275	0.923**	0.975**
X9									1	0.043	0.343*
X10										1	0.916**
X11											1

*Significant at 5 % level **Significant at 1 % level

X1-Plant height (cm)
X2-Primary branches
X3-Secondary branches
X4-Days to 50 per cent flowering
X5-Days to maturity
X6-Umbels per plant
X7-Umbellet per umbel
X8-Seeds per umbel
X9-Test weight
X10-Harvest index
X11-Seed yield per plant (g)

Table 2: Phenotypic correlation coefficient among yield and yield attributing characters in ajwain genotypes

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
X1	1	0.367*	-0.746 **	-0.21	-0.094	0.686 **	0.601 **	0.649 **	0.532 **	0.450 **	0.645**
X2		1	0.080	-0.567 **	-0.383 *	0.762 **	0.705**	0.782 **	-0.187	0.627 **	0.755**
X3			1	0.007	-0.120	-0.235	-0.238	-0.202	-0.672 **	-0.075	-0.252
X4				1	0.820 **	-0.461 **	-0.344*	-0.561 **	-0.082	-0.338 *	-0.653**
X5					1	-0.277	-0.151	-0.425 **	-0.099	-0.267	-0.557**
X6						1	0.752 **	0.931 **	0.223	0.586 **	0.879**
X7							1	0.759 **	0.280	0.513 **	0.711**
X8								1	0.228	0.645 **	0.918**
X9									1	-0.003	0.278
X10										1	0.665**
X11											1

*Significant at 5 % level **Significant at 1 % level

X1-Plant height (cm)
X2-Primary branches
X3-Secondary branches
X4-Days to 50 per cent flowering
X5-Days to maturity
X6-Umbels per plant
X7-Umbellet per umbel
X8-Seeds per umbel
X9-Test weight
X10-Harvest index
X11-Seed yield per plant (g)

Table 3: Genotypic path coefficient analysis of yield attributing characters on seed yield per plant in ajwain genotypes

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	rG
X1	0.985	-0.517	0.932	0.302	0.127	-0.971	-0.886	-0.961	-0.969	-0.964	0.728**
X2	0.148	0.380	0.047	-0.241	-0.160	0.306	0.283	0.319	-0.073	0.445	0.796**
X3	0.819	-0.125	-0.923	0.007	0.134	0.249	0.246	0.220	0.778	0.021	-0.257
X4	0.603	-0.137	-0.382	-0.004	0.552	-0.299	-0.247	-0.362	-0.039	-0.381	-0.728**
X5	-0.559	0.058	0.258	0.080	-0.610	0.195	0.109	0.285	0.097	0.351	-0.626**
X6	-0.080	0.118	0.129	-0.039	-0.051	0.160	0.128	0.156	0.045	0.184	0.927**
X7	-0.015	0.024	0.027	-0.009	-0.007	0.029	0.036	0.030	0.013	0.037	0.760**
X8	-0.656	0.795	0.920	-0.237	-0.511	0.915	0.905	0.932	0.301	0.985	0.975**
X9	-0.012	0.136	-0.036	-0.142	-0.030	0.052	0.065	0.051	0.186	0.008	0.343*
X10	-0.077	0.089	0.143	-0.003	-0.070	0.140	0.124	0.142	0.005	0.121	0.916**

Residual Effect: 0.128 rG-Genotypic correlation value of seed yield per plant

X1-Plant height (cm)
X2-Primary branches
X3-Secondary branches
X4-Days to 50 per cent flowering
X5-Days to maturity
X6-Umbels per plant
X7-Umbellet per umbel
X8-Seeds per umbel
X9-Test weight
X10-Harvest index
X11-Seed yield per plant (g)

Table 4: Phenotypic path coefficient analysis of yield attributing characters on seed yield per plant in ajwain genotypes

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	rP
X1	-0.072	-0.027	0.054	0.015	0.007	-0.050	-0.044	-0.047	-0.039	-0.033	0.645**
X2	0.020	0.053	0.004	-0.030	-0.020	0.040	0.037	0.041	-0.010	0.033	0.755**
X3	0.116	-0.012	-0.155	-0.001	0.019	0.036	0.037	0.031	0.104	0.012	-0.252
X4	0.002	-0.003	-0.009	0.001	0.001	-0.007	-0.005	-0.001	-0.001	-0.005	-0.653**
X5	0.028	0.115	0.036	-0.246	-0.300	0.083	0.045	0.128	0.030	0.080	-0.557**
X6	0.285	0.317	-0.098	-0.192	-0.115	0.416	0.313	0.387	0.093	0.243	0.879**
X7	0.041	0.048	-0.016	-0.023	-0.010	0.051	0.068	0.051	0.019	0.035	0.711**
X8	0.145	0.174	-0.045	-0.125	-0.095	0.208	0.169	0.223	0.051	0.144	0.918**
X9	0.016	-0.006	-0.021	-0.003	-0.003	0.007	0.009	0.007	0.031	-0.001	0.278
X10	0.068	0.095	-0.011	-0.051	-0.040	0.088	0.078	0.097	-0.001	0.151	0.665**

Residual Effect: 0.274 rP-Phenotypic correlation value of seed yield per plant

X1-Plant height (cm)
X2-Primary branches
X3-Secondary branches
X4-Days to 50 per cent flowering
X5-Days to maturity
X6-Umbels per plant
X7-Umbellet per umbel
X8-Seeds per umbel
X9-test weight
X10-Harvest index
X11-Seed yield per plant (g)

Conclusion

Seed yield per plant was influenced significantly and positively by plant height, primary branches per plant, umbels per plant, umbellate per umbel, seeds per umbel and harvest index at both genotypic and phenotypic levels. The positive direct association of primary branches, umbels per plant, Umbellet per umbel, seeds per umbel, test weight and harvest index with seed yield is significant. Thus, it is evident that seed yield is a complex biometric trait associated with plant growth, reproductive and yielding traits. Therefore, it is mandatory to select suitable traits for further crop improvement.

Reference

1. Anonymous. Spices statistics. Spice Board, Ministry of Commerce and Industry, Government of India, Cochin; c2018.
2. Bahraminejad A, Nejad MG, Khadir AM. Genetic diversity evaluation of cumin (*Cuminum cyminum* L.) based on phenotypic characteristics. Australian Journal of Crop Science. 2011;5(3):304-10.
3. Bairwa R, Sodha RS, Rajawat BS. *Trachyspermum ammi*. Pharmacognosy Reviews. 2012;6(11):56-60.
4. Chatterjee ASC. The treatise of Indian medicinal plants. 2nd ed. New Delhi: Publication and Information Directorate, CSIR; c1995.
5. Chauhan B, Kumar G, Ali M. Composition of volatile oil of *Carum copticum* benth and hook fruits. International Research Journal of Pharmacy. 2012;3(7):131-2.
6. Dubey S, Kashyap P. *Trachyspermum ammi*: A review on its multidimensional uses in Indian folklore medicines. Journal of Medicinal Plants Research. 2015;9:368-74.
7. Hassanshahian M, Bayat Z, Saeidi S, Shiri Y. Antimicrobial activity of *Trachyspermum ammi* essential oil against human bacterial. International Journal of Advanced Biological and Biomedical Research. 2014;2(1):18-24.
8. Faravani M, Jafari AA, Ranjbar M, Negari KA, Azizi N. Correlation and path coefficient analysis of phenological, agronomic and morphological traits of cumin and ajwain populations in Iran. Selcuk Journal of Agriculture and Food Sciences. 2018;32(3):482-95.
9. Farooqi AA, Sreeramu BS, Srinivasappa KN. Cultivation of spice crops. Hyderabad: Universities Press (India) Private Limited; c2005. p. 42-7.
10. Ghanshyam, Dodiya NS, Sharma SP, Jain HK, Dashora A. Assessment of genetic variability, correlation and path analysis for yield and its components in ajwain (*Trachyspermum ammi* L.). Journal of Spices and Aromatic Crops. 2015;24(1):43-6.
11. Gersbach PV, Reddy N. Non-invasive localization of thymol accumulation in *Carum copticum* (Apiaceae) fruits by chemical shift selective magnetic resonance imaging. Annals of Botany. 2002;90(2):253-7.
12. Gurjar M, Naruka IS, Shaktawat RPS. Variability and correlation analysis in fenugreek (*Trigonella foenum-graecum* L.). Legume Research. 2016;39(3):459-65.
13. Jain A, Singh B, Solanki RK, Saxena SN, Kakani RK. Genetic variability and character association in fenugreek (*Trigonella foenum-graecum* L.). International Journal of

Seed Spices. 2013;3(2):22-8.
14. Kassaun MB, Alemaw G, Tesfaye B. Correlation studies and path coefficient analysis for seed yield and yield components in Ethiopian coriander accessions. The Journal African Crop Science Society. 2013;21(1):51-9.
15. Lal G. Scenario, importance and prospects of seed spices: A review. Current Investigations in Agriculture and Current Research. 2018;4(2):491-8.
16. Panse VG, Sukhatme PV. Statistical methods for agriculture workers. New Delhi: Indian Council of Agricultural Research; c1957. p. 152-74.
17. Patahk AR, Patel AI, Joshi HK, Patel DA. Genetic variability, correlation and path coefficient analysis in fenugreek (*Trigonella foenum-graecum* L.). BioScience Trends. 2014;7(4):234-7.
18. Meena YK, Kale VS, Meena OP. Correlation coefficient and path analysis in coriander. International Journal of Scientific Research and Publications. 2014;4(6):1-4.
19. Mohsenzadeh S, Zaboli J, Jaime A, Silva TD. Allelopathic potential of ajwain (*Trachyspermum copticum*). Medicinal and Aromatic Plant Science and Biotechnology. 2012;6(1):72-4.
20. Muvel R, Naruka IS, Chundawat RS, Shaktawat RPS, Rathore SS, Verma KS. Production, productivity and quality of ajwain (*Trachyspermum ammi* L. Sprague) as affected by plant geometry and fertilizer levels. International Journal of Seed Spices. 2015;5(2):32-7.
21. Ranjeetha R, Vishnuvardhana, Ramegowda GK, Ramachandra RK, Sangeetha CG, Venkatesh J. Insect pest spectrum on ajwain, *Trachyspermum ammi* L. genotypes under eastern dry zone of Karnataka. Journal of Entomology and Zoology Studies. 2020;8(6):786-9.
22. Ranjeetha R, Vishnuvardhana, Ramachandra RK, Ramegowda GK, Sangeetha CG, Venkatesh J. Assessment of ajwain (*Trachyspermum ammi* L.) genotypes for reproductive and yield attributes under eastern dry zone of Karnataka. Biological Forum-An International Journal. 2021;13(4):508-11.
23. Ravindrababu Y, Prajapati DB, Patel KR. Characterization and evaluation of indigenous ajwain (*Trachyspermum ammi*) germplasms under North Gujarat condition. International Journal of Seed Spices. 2012;2(1):59-62.
24. Singh SP, Choudary BD. Biometrical methods in quantitative genetic analysis. Ludhiana: Kalyani Publishers; 1985. p. 318.
25. Singh PP, Gujar M, Naruka IS. Association and path analysis in fenugreek (*Trigonella foenum-graecum*). Indian Journal of Agricultural Science. 2016;86(7):951-5.
26. Solemani B, Khosh-Khui M, Sadrollah R. Planting date effect on growth, seed yield, essential oil content and chemical composition of ajwain. Journal of Applied Biological Science. 2011;5(3):7-11.