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Correlation and Path Analysis in Ajwain (*Trachyspermum ammi* L.)

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ABSTRACT: Ajwain is an aromatic seed spice which is cultivated mainly for its seed, herb and volatile oil. The narrow genetic base and allogamy are the major challenges in the crop improvement of ajwain. The study on the relationship between yield and its components will improve the efficiency of breeding programs by determining appropriate selection criteria. An investigation was carried out in 16 genotypes of ajwain to study the association among yield components and their direct and indirect effects on seed yield. Positive correlations were observed between seed yield per plant with number of umbels per plant (0.975), harvest index (0.882), number of branches (0.623), test weight (0.531), number of flowers per umbel (0.511) and number of seeds per umbel (0.457). Genotypic path coefficient analysis indicated that plant height at 150 DAS, days to 50 per cent flowering, number of flowers per umbel, number of umbellate per umbel, harvest index and test weight had positive direct effect on seed yield of ajwain.

Keywords: Ajwain, *Trachyspermum ammi*, genotypes, umbels, umbellate.

INTRODUCTION

India is known as a land of spices as no country in the world produces as many varieties of spices. India is the largest producer, consumer and exporter of spices. International Organization for Standardization (ISO) has identified more than 112 plant species as spices, out of which 63 spices are being grown in India, among that 20 are seed spices (Tomar and Malik, 2014). Ajwain (Oma/Carum seed/Bishop's weed) is one of the minor seed spices, botanically known as *Trachyspermum ammi* (L.) belongs to the family apiaceae. It is an important *rabi* season seed spice with a diploid chromosome number of 2n=18. Ajwain is native to Egypt and it is mainly cultivated in eastern India, Egypt, Persia, Afghanistan, Pakistan and Iran. The major ajwain importing countries are Yemen, Dubai, Malaysia, Pakistan, Saudi Arabia, Indonesia, Singapore, UAE and USA (Tomar and Malik, 2014). In India, ajwain is cultivated in Rajasthan, Gujarat, Madhya Pradesh, Uttar Pradesh, Maharashtra, West Bengal, Bihar, Telangana and Andhra Pradesh (Mohsenzadeh *et al*., 2012). During 2018-19, 25,000 t of ajwain seeds were produced from 35,000 hectare area. The present productivity of ajwain is 0.71 t/ha.

Rajasthan is the major ajwain producing state with an area of 15,430 ha and annual production of 10,540 t. Rajasthan contributes 73 per cent of total ajwain production in India. In south India, Telangana is leading in production *i.e*. 5,720 t from an area of 1,380 ha. In recent years, huge scale cultivation of ajwain is being taken up in Gulburga, Raichur, Vijayapur and Bagalkote, areas of Karnataka (Anon., 2018). Ajwain seeds contain an essential oil, which consists nearly 50 per cent of thymol along with γ-terpinene (3.83%) and cymene (3.37%). It has a strong anti-spasmodic, fungicidal and germicidal effect (Bhatt *et al*., 2018). Most important use of ajwain is the home remedy for indigestion. Its seeds and oils are largely used for its stimulant, antioxidants, preservatives, aromatic and carminative properties, the other major use of ajwain in flavoring of foods (Muvel *et al*., 2015).

Ajwain is mainly a dry land crop which can be grown with less amount of water and least inputs. In spite of this, crop is grown in less area, so there's a scope for further expansion of area under ajwain in dry land regions with high yielding varieties or genotypes. These genotypes play very critical role in optimizing the yield,

as they have differential adaptability to diverse agro climatic conditions. The selection of genotypes basically depends on the soil and climatic conditions, which are prevailing in the area because of changing length of growth season, flowering and maturity. Till date very limited numbers of genotypes are used for assessing the variability, correlation and path analysis. In the present study, released varieties, varieties proposed for release, accessions which are under evaluation are included which gives an accurate and broad understanding of the association of morphometric and yield characters. The length of growing season of ajwain in Karnataka is short compared to that prevailing in Rajasthan (Solemani *et al.*, 2011). Hence, there's need to test the available genotypes under northern dry zone of Karnataka. Therefore, the present study was carried out to evaluate the 16 ajwain genotypes for growth, yield and quality traits and their association.

MATERIAL AND METHODS

The present investigation on was undertaken during *rabi* in 2019-20 at Department of Plantation, Spices, Medicinal and Aromatic Crops (PMA), College of Horticulture, Bagalkote to study the performance of elite ajwain (*Trachyspermum ammi* L.) genotypes. Sixteen genotypes (Table 1) were grown in Randomized Complete Block Design (RCBD) with four replications at spacing of 45 cm × 30 cm. All the recommended agronomical practices and plant protection measures were adopted to raise a healthy crop to attain maturity. Recommended dose of fertilizer (100: 50: 50 NPK kg ha^{-1}) was applied in the form of SSP at the rate of 312.50 kg ha^{-1}, urea at 217.00 kg ha^{-1} and MOP at 83.00 kg ha^{-1}. Full dose of potash, phosphorous and half dose of nitrogen were applied as basal dose and remaining nitrogen was given after 30 days after sowing (DAS). The seeds were line sown as per the recommended seed rate (2.5 kg ha^{-1}). Seeds were sown in individual plots separately. Totally, 15 irrigations were given during the experimental period. Observation were taken on each genotype for growth, yield and quality traits *viz.*, days to germination, plant height, number of branches, days to 50 per cent flowering, number of flowers per umbel, number of umbels per plant, number of seeds per umbel, number of umbelletes per umbel, seed yield, test weight, harvest index, essential oil content and oleoresin content. Mean data from each of the replications were used for analysis. The essential oil percentage was determined by steam distillation method by clevenger apparatus (Sadgrove and Jones, 2015) and oleoresin was extracted by using soxhlet apparatus (Sontakke *et al.*, 2018).

Table 1: Genotypes and source of collection.

Sr. No.	Genotypes	Source
1.	Ajmer Ajwain -1 (AA-1)	NRCSS, Ajmer, Rajasthan.
2.	Ajmer Ajwain -2 (AA-2)	NRCSS, Ajmer, Rajasthan.
3.	Ajmer Ajwain -93 (AA-93)	NRCSS, Ajmer, Rajasthan.
4.	Ajwain Local -3 (AL-3)	NRCSS, Ajmer, Rajasthan.
5.	Ajwain Local -4 (AL-4)	NRCSS, Ajmer, Rajasthan.
6.	Ajwain Local -5 (AL-5)	NRCSS, Ajmer, Rajasthan.
7.	Gujarat Ajwain -1 (GA-1)	Sardarkrushinagar Dantiwada Agricultural University, Gujarat.
8.	Lam Selection-1 (LS-1)	RARS, Guntur, Andhra Pradesh.
9.	LTa-26	RARS, Guntur, Andhra Pradesh.
10.	DAC-1	Horticulture Research and Extension and Centre (HREC), Devihosur, Haveri.
11.	DAC-2	HREC, Devihosur, Haveri.
12.	DAC-3	HREC, Devihosur, Haveri.
13.	DAC-4	HREC, Devihosur, Haveri.
14.	DAC-5	HREC, Devihosur, Haveri.
15.	DAC-6	HREC, Devihosur, Haveri.
16.	DAC-7	HREC, Devihosur, Haveri.

Table 2: Genotypic correlation for yield and yield related traits in ajwain.

@	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
X_1	**1.00**	0.067	-0.430*	-0.502**	0.137	0.315*	0.024	0.151	-0.259*	-0.001	-0.216	-0.204	0.223
X_2		**1.00**	0.062	0.033	0.578**	0.524**	0.272*	0.510**	0.606**	0.604**	0.658**	-0.054	0.623**
X_3			**1.00**	0.998**	0.040	-0.349**	0.192	0.50	-0.029	-0.070	0.445**	-0.006	-0.238
X_4				**1.00**	-0.042	-0.398**	0.145	-0.036	-0.047	-0.096	0.465**	0.011	-0.283*
X_5					**1.00**	0.393**	0.778**	0.990**	0.466**	0.515**	0.468**	-0.137	0.511**
X_6						**1.00**	0.029	0.354**	0.833**	0.464**	0.014	0.116	0.975**
X_7							**1.00**	0.814**	0.173	0.303*	0.478**	-0.429**	0.158
X_8								**1.00**	0.406**	0.570**	0.408**	-0.238	0.457**
X_9									**1.00**	0.602**	0.307*	0.218	0.882**
X_{10}										**1.00**	0.338**	-0.137	0.531**
X_{11}											**1.00**	-0.086	0.199
X_{12}												**1.00**	0.201
X_{13}													**1.00**

** Significant at 1 per cent level of probability
* Significant at 5 per cent level of probability
X_1- Plant height (cm) at 150 DAS
X_2 - Number of branches
X_3 - Days to (50%) flowering
X_4- Days to (90%) flowering
X_5 - Number of flowers per umbel
X_6 - Number of umbels per plant
X_7 - Number of umbellates per umbel
X_8 - Number of seeds in an umbel
X_9 - Harvest index (%)
X_{10}- Test weight (g)
X_{11}- Essential oil (%)
X_{12}- Oleoresin (%)
X_{13}- Seed yield of a plant (g)

Table 3: Genotypic path for yield and yield related traits in ajwain.

@	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	rG
X_1	**0.530**	-0.008	-0.237	0.266	0.178	-0.031	0.002	-0.216	-0.276	0.000	0.011	0.004	0.223
X_2	0.035	**-0.114**	0.034	-0.017	0.752	-0.052	0.027	-0.730	0.646	0.075	-0.035	0.001	0.623**
X_3	-0.228	-0.007	**0.553**	-0.528	0.052	0.035	0.019	-0.071	-0.031	-0.009	-0.023	0.000	-0.238
X_4	-0.266	-0.004	0.551	**-0.529**	-0.054	0.039	0.015	0.051	-0.050	-0.012	-0.025	0.000	-0.283*
X_5	0.072	-0.066	0.022	0.022	**1.300**	-0.039	0.079	-1.418	0.496	0.064	-0.025	0.002	0.511**
X_6	0.167	-0.060	-0.193	0.210	0.511	**-0.099**	0.003	-0.506	0.887	0.058	-0.001	-0.002	0.975**
X_7	0.012	-0.031	0.106	-0.077	1.011	-0.003	**0.101**	-1.166	0.184	0.038	-0.025	0.007	0.158
X_8	0.080	-0.058	0.027	0.019	1.288	-0.035	0.082	**-1.431**	0.432	0.071	-0.022	0.004	0.457**
X_9	-0.137	-0.069	-0.016	0.025	0.606	-0.083	0.017	-0.581	**1.065**	0.075	-0.016	-0.004	0.882**
X_{10}	0.000	-0.069	-0.039	0.051	0.670	-0.046	0.031	-0.817	0.641	**0.124**	-0.018	0.002	0.531**
X_{11}	-0.114	-0.075	0.246	-0.246	0.608	-0.001	0.048	-0.584	0.326	0.042	**-0.053**	0.001	0.199
X_{12}	-0.108	0.006	-0.003	-0.006	-0.178	-0.011	-0.043	0.341	0.233	-0.017	0.005	**-0.017**	0.201

Residual effect = 0.144
rG- Genotypic correlation value of seed yield/plant
** Significant at 1% level of probability
* Significant at 5% level of probability
X_1- Plant height (cm) at 150 DAS
X_2 - Number of branches
X_3 - Days to (50%) flowering
X_4- Days to (90%) flowering
X_5 - Number of flowers in an umbel
X_6 - Number of umbels in a plant
X_7 - Number of umbellates in an umbel
X_8 - Number of seeds in an umbel
X_9 - Harvest index (%)
X_{10}- Test weight (g)
X_{11}- Essential oil (%)
X_{12}- Oleoresin (%)

RESULTS AND DISCUSSION

Genotypic correlation for growth and yield traits in ajwain are depicted in Table 2. The plant height at 150 DAS had significant and positive link with number of umbels per plant (0.315), but it was significant and negatively associated with days to commencement of 50 per cent flowering (-0.430), days to commencement of 90 per cent flowering (-0.502) and harvest index (-0.259), whereas the plant height at 150 DAS had positive and non-significant association with number of branches (0.067), number of flowers in an umbel (0.137), number of umbellates per umbel (0.024), number of seeds in an umbel (0.151) and seed yield of single plant (0.223). The plant height had negative and non-significant association with test weight (-0.001), essential oil (-0.216), oleoresin content (-0.204). Hence, it can be concluded that the plant height had negative association with majority of yield contributing characters. These results are in conformity with the findings of Rawat *et al.*, (2020).

Number of branches showed positive and significant association with number of flowers per umbel (0.578), number of umbels in a single plant (0.524), number of umbellates per umbel (0.272), number of seeds in an umbel (0.510), test weight (0.604), essential oil (0.658), seed yield of a single plant (0.623) and harvest index (0.606), while, this was non-significant and positively associated with days to commencement of 50 per cent flowering (0.062), days to commencement of 90 per cent flowering (0.033) and negatively correlated with oleoresin content (-0.054). More number of branches and spreading of plant has positive association with the majority of the characters under study, Hence, spreading type ajwain genotypes should be preferred for crop improvement and selection. Ravindrababu *et al.*, (2012) obtained the similar findings in ajwain.

Days to commencement of 50 per cent flowering had significant and positive relation with days to commencement of 90 per cent flowering (0.998) and essential oil (0.445), whereas, negatively linked with number of umbels in a single plant (-0.349). This character had non-significant and positively associated with number of flowers per umbel (0.040), number of umbellates per umbel (0.192), number of seeds in an umbel (0.50) and negatively correspondence with harvest index (-0.029), test weight (-0.070), oleoresin content (-0.006) and seed yield of a single plant (-0.238). It is confirmed that early flowering types are low yielders than long duration one. These results are in conformity with the results of Meena, (2012); Giridhar *et al*., (2017).

Days taken to 90 per cent flowering in ajwain owned positive and significant association with essential oil (0.465), while it was negative correspondence with seed yield of a plant (-0.283) and number of umbels in single plant (-0.398). It showed positive and non-significant correspondence with number of umbellates per umbel (0.145), oleoresin content (0.011) and negatively correlated with number of flowers in an umbel (-0.042), number of seeds in an umbel (-0.036), harvest index (-0.047) and test weight (-0.096). Similar results were obtained by Yadav (1999) in coriander and Shivaprasd *et al*., (2018) in fennel.

Number of flowers in an umbel owned positive and significant relation with total number of umbels in a plant (0.393), number of umbellates in an umbel (0.778), number of seeds per umbel (0.990), harvest index (0.466), test weight (0.515), essential oil (0.468) and seed yield of a plant (0.511). It showed negative and non-significant association with oleoresin content (-0.137). More number of flowers in a plant produces more yield and aromatic seeds. Similar results were also obtained by Verma *et al.*, (2018).

Number of umbels in a plant had exhibited significant and positive correspondence with number of seeds in an umbel (0.354), harvest index (0.833), test weight (0.464) and seed yield in a plant (0.975), while, the positive and non-significant association was noticed for number of umbellate per umbel (0.029), essential oil (0.014) and oleoresin content (0.116). Hence, more number of umbel per plant had positive impact on yield. These results in conformity with the results of Saxena *et al.*, (2016); Singh & Chaudhari (2008) in fennel and ajwain respectively.

Number of umbellate in an umbel showed positive and significant correspondence with number of seeds per umbel (0.814), test weight (0.303), essential oil (0.478) and negative correlation with oleoresin content (-0.429). This trait had non-significant and positive correlation with the harvest index (0.173) and seed yield of a plant (0.158). These results are in conformity with the findings of Shivarprasad *et al.*, (2018) in fennel. Hence, less number of umbellate per umbel results in less yield whereas, quality in terms of essential oil is good if the number of umbellate per umbel is more.

Number of seeds in an umbel had positive and significant correspondence with harvest index (0.406), test weight (0.570), essential oil (0.408) and seed yield of a plant (0.457), while it was negative and non-significantly associated with oleoresin content (-0.238).

Harvest index exhibited positive and significant relation with test weight (0.602), essential oil (0.307) and seed yield of a plant (0.882), while, it showed non-significant and positive association with oleoresin content (0.218). Test weight exhibited positive and significant correspondence with essential oil (0.338) and seed yield of a plant (0.531), while it was negative and non-significantly linked with oleoresin content (-0.137). Harvest index is has direct influence on seed yield and essential oil content.

Essential oil content in ajwain owned positive and non-significant correspondence with seed yield of a plant (0.199), whereas negatively associated with oleoresin

content (-0.086). Oleoresin content had positive and non-significant relation with seed yield of a plant (0.201). These findings are in line with the reports of Meena and Dhakar, (2017); Rawat *et al.*, (2020); Singh *et al*., (2020).

Genotypic path coefficient analysis indicated that plant height at 150 DAS (0.530), days to 50 per cent flowering (0.553), number of flowers per umbel (1.300), number of umbellate per umbel (0.101), harvest index (1.065) and test weight (0.124) had positive direct effect on seed yield of ajwain. The residual effect was low (0.144) for this present experiment, which indicates that much of variation in seed yield has been considered and selection of the traits were accurate and needs additional consideration. Similar reports were obtained by Ghanshyam *et al.*, (2015); Rawat *et al.*, (2020).

CONCLUSION

Genotypic correlation analysis indicated that seed yield per plant had highly significant and positive association with the number of branches per plant, number of flowers per umbel, number of umbels per plant, number of seeds per umbel, harvest index and test weight. Genotypic path coefficient analysis indicated that plant height at 150 DAS, days to 50 per cent flowering, number of flowers per umbel, number of umbellate per umbel, harvest index, and test weight had positive direct effect on seed yield of ajwain. The positively associated characters can be used for crop improvement programme in future.

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Conflict of Interest. Nil.

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