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Correlation coefficient and path analysis in fennel

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Abstract
The field experiment was carried out during *Rabi* season of the year 2019-20 at the Department of Seed Technology Farm, Sardarkrushinagar Dantiwada Agricultural University, S K Nagar, Dantiwada, Gujarat. The study was undertaken on 40 genotypes of Fennel (*Foeniculum vulgare* Miller) using Randomized Block Design with three replications. This study revealed that seed yield per plant found to be positively and significantly correlated with number of umbels per plant, number of umbellates per main umbel, seeds per umbel and 1000-seed weight. These yield contributing characters also possessed highly significant and positive correlation among themselves. Seed yield per plant also have positive correlation with plant height at genotypic level. Path coefficient analysis indicated that the highest positive direct effect of number of umbels per plant followed by days to flowering, number of umbellates per main umbel, 1000-seed weight, seed oil content and plant height. Days to maturity, number of branches per plant and seeds per umbel had negative direct effect. The highest indirect effect was via days to maturity, number of branches per plant and seeds per umbel. The genetic correlation of number of umbels per plant, number of umbellates per main umbel, seeds per umbel and 1000-seed weight were also positive and highly significant with seed yield per plant.

Keywords: correlation, path analysis, fennel

Introduction

Fennel (*Foeniculum vulgare* Mill.*)* belonging to the family Apiaceae, is a cross pollinated crop and a diploid species with chromosome number 2n=22. It is a native of Europe and the Mediterranean region. Fennel is an annual, aromatic herb of 100-180 cm height having a slender, branched, smooth stem which becomes hollow at maturity with distinct veins. Leaves are alternate, decompounded and have sheathed petiole. The inflorescence is terminal bearing compounded umbel subtended by involucres of bracts. Flowers are small, hermaphrodite, complete, regular and pentamerous. The fruit commonly known as a seed is a schizocarp of two mericarps attached to dividing carpophores. A fully-grown fruit is 4 to 8 mm long. The size and the colour of the fruit depending on the stage of harvesting. The fish-string like leaves are valued as a source of flavour to garnish and also possess diuretic properties. The root is regarded as a purgative. Fennel fruits are used in diseases like cholera, bile disturbances, nervous disorders, constipation and dysentery and also used for control of diseases attacking the chest, lungs and kidney and in colic pain. In India, these seeds are also used for mastication and chewing either alone or with betel leaves.

The seeds contain about 9.5% protein, 10.0% fat, 42.3% carbohydrate, 18.5% crude fibre and 13.4% minerals. The seeds contain about 0.7 to 6.0% volatile oil depending upon genotype and botanical types. A 100 grams portion of fennel seeds provides 345 kilo calories energy and a rich source of protein, dietary fibre, vitamins and several dietary minerals like calcium, magnesium, manganese, all of which exceeds 100% DV. The main constituent of the fennel oil is anethole and fenchone. The volatile oil is primarily beneficial for the digestive system and also exhibits vermicidal, antispasmodic and anti-flatulence properties.

The concept of correlation was first proposed by Galton (1889) [6] and later it was elaborated by fisher (1918). Correlation coefficient is rated as significant only when observed values are higher than the estimated value. For yield improvement in fennel through selection, the knowledge of the correlation between yield contributing characters is essential. A correlation study provides an opportunity to study the magnitude and direction of association of yield with its components and also among themselves. Path coefficient analysis was developed by Wright (1921) [1] and further elaborated by Dewey and Lu (1959) [5]. Path analysis is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects. Path analysis measures the cause of association between two variables.

The study of various traits and their association with each other is an important strategy designated to break genetic barriers of yield. Correlation studies help determine the components of a complex trait like yield. However, they do not provide an exact magnitude of direct and indirect effects towards yield. In this context, path coefficient analysis is an important tool to partition the correlation coefficient into the direct and indirect effects of the independent variables on the dependent variables. This information may be useful to the breeder in selecting high yielding genotypes in any crop.

The present research work was undertaken to investigate the relative importance of direct and indirect influences of the component traits toward seed yield; and identify the important traits to be considered in fennel improvement programmes.

Materials and Methods

The present investigation was conducted at Department of Seed Technology, Sardarkrushinagar Dantiwada Agricultural University, S K Nagar, Dantiwada, Gujarat. There were 40 genotypes included in study, collected from Seed Spice Research Station, Jagudan, S D agricultural University, Gujarat. Geographically, Sardarkrushinagar is positioned at 24°-19° North Latitude & 72°-19° East Longitude with an altitude of 154.52 meters above mean sea level. The weather during the crop season was normal and favourable for crop growth. The row to row and plant to plant spacing was maintained at 90 x 60 cm. in each replication five plants were randomly selected were marked for observations. Observations were recorded for ten characters *viz.* days to flowering, days to maturity, plant height, number of branches per plant, number of umbels per plant, number of umbellates per main umbel, number of seeds per main umbel, 1000-seed weight, volatile oil content in seeds and seed yield per plant.

The analysis of variance for testing the variation among treatments was carried out as per the method suggested by Panse and Sukhatme (1978). The genotypic and phenotypic correlation coefficient was calculated as per the method given by Al-Jibouri *et al.* (1958) [2]. Path analysis based on genotypic correlation was performed according to Dewey & Lu (1959) [5].

Results and Discussion

Analysis of variance revealed highly significant difference among genotypes for all traits studied indicating presence of significant amount of variability in the materials.

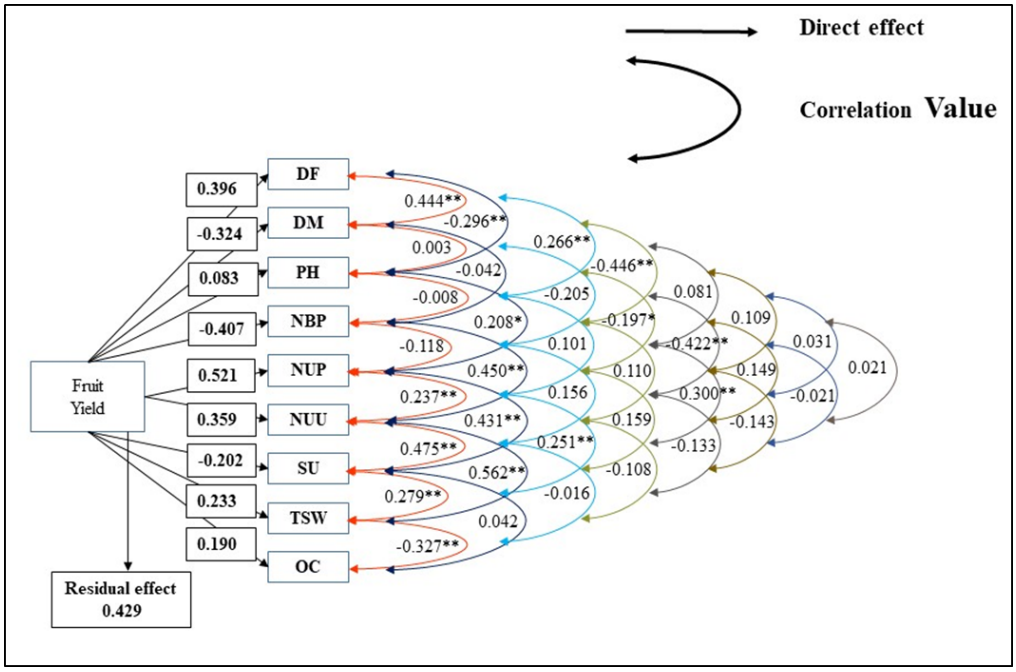
A polygenic trait like yield, which is interrelated with number of contributing characters, it is imperative to obtain information regarding the interrelationship of different characters with yield and themselves, since it facilitates the quicker assessment of high yielding genotypes in selection programme. Estimation of only phenotypic correlation coefficient is not sufficient to understand complete association between characters, as it is the result of interaction between the genotypes and environment. The real association could be known only through genotypic correlation, which eliminates the environmental effects. Hence, in the present investigation the genotypic and phenotypic correlation coefficient were worked out between seed yield per plant and component traits.

The correlation coefficient between seed yield per plant and nine traits and among themselves was estimated at phenotypic and genotypic levels (Table 1). It was revealed that magnitude of genotypic correlations was higher than their corresponding phenotypic correlations. Seed yield per plant had highly positive and significant correlation with number of umbels per plant, number of umbellet per plant, seeds per umbel and 1000-seed weight at both levels. Days to flowering had highly positive and significant correlation with number of branches per plant at both levels. Plant height had highly positive and significant correlation with 1000-seed weight. Number of branches per plant had highly positive and significant correlation with number of umbellates per plant at both levels. Number of umbels per plant had highly positive and significant correlation with seeds per main umbel and seed yield per plant at both levels. Number of umbellates per plant had highly and positive correlation with seeds per main umbel, 1000-seed weight and seed yield per plant. Seeds per umbel had highly positive and significant correlation with 1000-seed weight and seed yield per plant. 1000-seed weight had highly positive and significant correlation with seed yield per plant. Present result indicated that the values of genotypic correlation were higher than phenotypic correlation except days to maturity (Table 1). This indicated that there was high degree of association between two variables at genotypic level, but its phenotypic expression was deflated by environment.

Table 1: Genotypic and phenotypic correlation coefficients among ten characters in fennel.

Characters	(r)	Days to maturity	Plant height (cm)	Number of branches per plant	Number of umbels per plant	Number of umbelate per umbel	Seeds per umbel	1000-seed weight (g)	Volatile Oil content (%)	Seed yield per plant (g)
Days to flowering	r_g	0.444**	-0.296**	0.266**	-0.446**	0.081	0.109	0.031	0.021	-0.095
	r_p	0.178	0.187*	0.203*	-0.330**	0.038	0.104	0.030	0.022	-0.083
Days to maturity	r_g		0.003	-0.042	-0.205*	-0.197*	-0.422**	0.149	-0.021	-0.192*
	r_p		0.037	-0.043	-0.115	-0.154	-0.279**	0.075	-0.011	-0.129
Plant height (cm)	r_g			-0.008	0.208*	0.101	0.110	0.300**	-0.143	0.134
	r_p			-0.025	0.130	0.062	0.060	0.249**	-0.111	0.097
Number of branches per plant	r_g				-0.118	0.450**	0.156	0.159	-0.133	-0.209*
	r_p				-0.118	0.389**	0.154	0.116	-0.121	-0.196*
Number of umbel per plant	r_g					0.237**	0.431**	0.251**	-0.10	0.512**
	r_p					0.213*	0.401**	0.218*	-0.101	0.471**
Number of umbellet per umbel	r_g						0.475**	0.562**	-0.016	0.435**
	r_p						0.445**	0.521**	-0.013	0.412**
Seeds per umbel	r_g							0.279**	0.042	0.391**
	r_p							0.258**	0.039	0.363**
1000-seed weight (g)	r_g								-0.327**	0.371**
	r_p								-0.314**	0.348**
Volatile Oil content (%)	r_g									0.101
	r_p									0.098

*, ** significant at 5% and 1% level of significance, respectively



DF = Days to flowering, DM = Days to maturity, PH = Plant height (cm), NBPP= number of branches per plant, NUPP = Number of umbels per plant, NUPU= Number of umbelets per main umbel, SUP = Seeds per umbel, SW = Test weight (g), OC= Oil content.

Fig 1: Path diagram indicating direct and indirect effect of yield components and their correlation coefficient of 40 genotypes in fennel

Seed yield per plant showed highly significant and positive correlation with number of umbels per plant, number of umbellates per umbel, seeds per umbel and 1000-seed weight. These findings are in agreement with Kathiria (1980) [8], Shinde *et al.* (1985) [14], Jindal *et al.* (1986) [7], Patel (1995) [11], Singh *et al.* (2003) [15], Rajput *et al.* (2004) [12], Pareek *et al.* (2009) [10], Dashora and Sastry (2011) [4], Chaudhry (2012) [3], Yadav *et al.* (2013) [16], Sefidan *et al.* (2014), Kumar *et al.* (2017) [9].

Number of umbels per plant showed highly positive and significant correlation with seeds per main umbel and seed yield per plant at both genotypic and phenotypic levels. These findings are in agreement with Shinde *et al.* (1985) [14], Jindal *et al.* (1986) [7], Patel (1995) [11], Singh *et al.* (2003) [15], Rajput *et al.* (2004) [12]. Singh and Sastry (2005), Pareek *et al.* (2009) [10], Chaudhry (2012) [3], Yadav *et al.* (2013), Sefidan *et al.* (2014) and Kumar *et al.* (2017) [9].

Number of umbellates per umbel had highly positive and significant correlation with seeds per main umbel, 1000-seed weight, seed yield per plant and number of umbels per plant at both genotypic and phenotypic levels. These findings are in agreement with Kathiria (1980) [8], Pareek *et al.* (2009) [10], Dashora and Sastry (2011) [4], Yadav *et al.* (2013) [16] and Kumar *et al.* (2017) [9].

Seeds per main umbel showed highly positive and significant correlation with 1000-seed weight, seed yield per plant and number of umbellates per umbel at both genotypic and phenotypic levels. 1000-seed weight had highly positive and significant correlation with seed yield per plant, plant height, number of umbellates per umbel, number of umbels per plant and seeds per main umbel.

Yield is the sum total of the several component characters with directly or indirectly contributed to it. The information derived from the correlation studies indicated only mutual association among the characters. Whereas, path coefficient analysis helps in understanding the magnitude of direct and indirect contribution of each character on the dependent characters like seed yield. Partitioning of correlation coefficient into direct and indirect effects provide information about the nature and magnitude of effects of other characters on seed yield. The result of the present investigation on path coefficient analysis as presented in Table 2 revealed that number of umbels per plant (0522) had highest direct effect on seed yield followed by days to flowering (0.396), number of umbellates per umbel (0.359), 1000-seed weight (0.234), volatile oil content (0.190) and plant height (0.083).this indicate that seed yield could be improved by making selection on the basis of these characters. These findings are in agreement with Patel (1995) [11], Singh *et al.* (2003) [15], Meena *et al.* (2009), Safidan *et al.* (2014) and Jeeterwal *et al.* (2015).

Table 2: Direct and indirect effects of different characters on seed yield in fennel.

Characters	Days to flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of umbels per plant	Number of umbellates per umbel	Seeds per umbel	1000-seed weight (g)	Volatile Oil content (%)	Genotypic Correlation with seed yield per plant (g)
Days to flowering	0.396	-0.144	-0.025	-0.109	-0.233	0.029	-0.022	0.007	0.004	-0.095
Days to maturity	0.176	-0.324	0.000	0.017	-0.107	-0.071	0.086	0.035	-0.004	-0.192*
Plant height (cm)	-0.118	-0.001	0.083	0.003	0.108	0.036	-0.022	0.070	-0.027	0.134

Number of branches per plant	0.106	0.013	-0.001	-0.408	-0.061	0.162	-0.032	0.037	-0.025	-0.209*
Number of umbels per plant	-0.177	0.066	0.017	0.048	0.522	0.085	-0.087	0.059	-0.021	0.512**
Number of umbellates per main umbel	0.032	0.064	0.008	-0.184	0.123	0.359	-0.096	0.131	-0.003	0.435**
Seeds per umbel	0.043	0.137	0.009	-0.064	0.225	0.171	-0.203	0.065	0.008	0.391**
1000-seed weight (g)	0.012	-0.048	0.025	-0.065	0.131	0.202	-0.057	0.234	-0.062	0.371**
Volatile Oil content (%)	0.008	0.007	-0.012	0.054	-0.056	-0.006	-0.008	-0.076	0.190	0.101

Residual effect = 0.42961, *Significant at 5% level of significance, **Significant at 1% level of significance

Path coefficient analysis indicated that utility of characters like number of umbels peer plant, days to flowering, number of umbellates per umbel, 1000-seed weight, volatile oil content and plant height which showed highest positive direct effect on seed yield per plant. These are the major yield contributing traits for enhancing the yield of fennel.

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