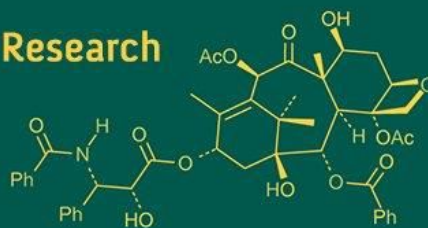
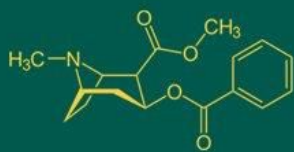


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; SP-8(12): 1506-1509
www.biochemjournal.com
Received: 22-09-2024
Accepted: 26-10-2024

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Path coefficient analysis of yield and yield components in fennel (*Foeniculum vulgare* Mill.) germplasm

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DOI: <https://doi.org/10.33545/26174693.2024.v8.i12Ss.3388>

Abstract

A total of 216 germplasms with six check varieties of fennel (*Foeniculum vulgare* Mill.) were evaluated for estimation of path analysis for yield improvement during Rabi season 2016-17 in augmented randomized complete block design in four blocks at Research Farm, SKN college of agriculture, Jobner. Path coefficient analysis revealed that test weight, umbellets per plant, seeds per umbel and umbels per plant exhibited positive direct effect on seed yield per plant, while plant height, days to maturity, days to 50 percent flowering and branches per plant exhibit negative direct effect on seed yield per plant. Out of 216 genotypes, 14 genotypes were better than the best check variety RF-125 on the basis of seed yield per plant. Some of the promising genotypes identified on the basis of seed yield per plant were UF-4, UF-16, UF-20, UF-23, UF-55, UF-61, UF-79, UF-88, UF-145, UF-149, UF-151, UF-168, UF-172 and UF-189. Therefore, it is inferred that for initiating breeding programmes of fennel, the primary emphasis should be given for selecting characters having direct effects on characters associated with higher yield. These superior genotypes can be used as donors in breeding programme.

Keywords: Path coefficient, genotypic and phenotypic level, direct and indirect effects, augmented randomized complete block design

Introduction

Fennel (*Foeniculum vulgare* Mill), a diploid species with chromosomal number $2n = 22$, is a cross-pollinated crop that belongs to the Apiaceae family. It is indigenous to the Mediterranean region and Europe. About 9.5% protein, 10.0% fat, 42.3% carbs, 18.5% crude fiber, and 13.4% minerals are present in the seeds. Depending on the botanical type or genotype, the volatile oil content of the seed's ranges from 0.7% to 6.0%. In a breeding program, these superior genotypes can serve as donors. In addition to being a rich source of protein, dietary fiber, vitamins, and various dietary minerals like calcium, iron, magnesium, and maganease, a 100-gram portion of fennel seeds offers 345 kcal of energy and more than 100% of the daily value. Fenchone and anethole are the primary components in fennel oil. The volatile oil has vermicidal, antispasmodic, and anti-flatulence qualities in addition to its primary benefits for the digestive tract. It is mostly grown in Gujarat and Rajasthan in India, with smaller amounts being grown in U.P., Karnataka, A.P., Punjab, M.P., Bihar, Haryana, and J & K. In India, the crop covers over 94070 hectares, yielding 135930 tonnes of output. India produces 1444.98 kg of fennel per hectare. It covers 25587 hectares in Rajasthan and produces 30717 tons annually. To some extent, it is grown in Bharatpur, Kota, and Ajmer, but it is mostly grown in the districts of Sirohi, Jodhpur, Nagour, Tonk, Dausa, and Pali and 1200.49 kg/ha of fennel are produced in Rajasthan. Any breeding program's ultimate objective is to enhance plant characteristics to make them more commercially and agronomically acceptable. Seed yield is a complex polygenic characteristic made up of a number of factors, some of which have a direct impact on yield and others that have an indirect one. Understanding the strength and direction of the relationship between yield and its constituent traits is crucial for breeding programs that aim to select desirable varieties. In such cases path coefficients analysis provides an effective clue due for this entangling direct as well as indirect effect of characters on dependable characters like seed yield.

Materials and Methods

The experimental material for the present investigation consisted of 216 germplasms obtained from germplasm collection of AICRP on Spices, S.K.N. College of Agriculture, Jobner, and six checks viz. RF-101, RF-125, RF-143, RF-157, RF-205, RF-281. The germplasm lines were evaluated during *Rabi* 2016-17 at Research Farm of S.K.N. College of Agriculture, Jobner in augmented randomized complete block design in four blocks with six checks viz., RF-101, RF-125, RF-143, RF-157, RF-205, RF-281 and plot size of 3.0 x 1.0 m². The row to row and plant to plant distance was maintained 50 cm and 20 cm respectively. Recommended cultural practices were followed to raise a healthy crop during the crop season. Each genotype was sown in a plot of two row of 3m length.

Results and Discussions

Two hundred sixteen genotypes of fennel along with six checks viz., RF-101, RF-125, RF-143, RF-157, RF-205 and RF-281 were evaluated in an augmented complete randomized block design in *Rabi* 2016-17 to estimate the direct and indirect effect of characters on seed yield.

In a breeding programme, we are often concerned with the improvement in yield which is an overall product depends on a number of morpho-physiological attributes. Such characters are often interrelated; hence their effects on seed yield are also modified by other. Path coefficient analysis helps in separating the direct effects of a component character on seed yield from indirect effects via other characters. The genotypic and phenotypic correlation coefficients of seed yield with its contributing characters were partitioned into direct and indirect effects through path coefficients analysis and are presented in table 1.0 both at genotypic and phenotypic levels.

Path coefficient analysis was carried out by taking seed yield as dependent variable and other components as independent variables. The trend in direct and indirect effects of different traits on seed yield was similar at genotypic and phenotypic levels. Also, the correlation of different traits significant with seed yield per plant which were primarily attributable to direct effects and contribution of indirect effect was low.

The analysis of path coefficient at phenotypic level revealed that test weight (0.7881), seeds per umbel (0.5963), days to maturity (0.0909), days to 50 percent flowering (0.0622) and umbellets per plant (0.0229) exhibited positive direct effect on the seed yield per plant, whereas branches per plant (-0.0473), plant height (-0.2385) and umbels per plant (-0.5020) exhibited negative direct effect. Path coefficient analysis at genotypic level revealed that test weight (0.6854), seeds per umbel (0.6192), days to maturity (0.2499), umbellets per plant (0.1031), days to 50 percent flowering (0.0351) and branches per plant (0.0092) exhibited positive direct effect on seed yield per plant, whereas plant height (-0.4979) and umbels per plant (-0.5897) exhibited negative direct effect.

At phenotypic level the days to 50 percent flowering showed positive indirect effect on seed yield through umbels per plant (0.4714) and days to maturity (0.0515), whereas negative indirect effect through branches per plant (-0.0009), umbellets per plant (-0.0205), plant height (-0.1435), test weight (-0.4705) and seeds per umbel (-0.5271). At genotypic level days to 50 percent flowering exhibited positive indirect effect on seed yield per plant

through umbels per plant (0.5050) and days to maturity (0.1038), whereas negative indirect effect through branches per plant (-0.0014), umbellets per plant (-0.0844), plant height (-0.2502), test weight (-0.3242) and seeds per umbel (-0.4943).

At phenotypic level days to maturity showed positive indirect effect on seed yield through umbels per plant (0.2932) and days to 50 percent flowering (0.0352), whereas negative indirect effect through umbellets per umbel (-0.0134), branches per plant (-0.0171), plant height (-0.223), seeds per umbel (-0.3413) and test weight (-0.6652). At genotypic level days to maturity exhibited positive indirect effect on seed yield per plant through umbels per plant (0.2855), days to 50 percent flowering (0.0146) and branches per plant (0.0033), whereas negative indirect effect through umbellets per plant (-0.0554), seeds per umbel (-0.3152), plant height (-0.4630) and test weight (-0.5495).

At phenotypic level, plant height showed positive indirect effect on seed yield through umbels per plant (0.3121), days to maturity (0.0850) and days to 50 percent flowering (0.0374), whereas negative indirect effect through umbellets per umbel (-0.0142), branches per plant (-0.021), seeds per umbel (-0.3732) and test weight (-0.6884). At genotypic level, plant height exhibited positive indirect effect through umbels per plant (0.3478), days to maturity (0.2324), plant height (0.0176) and branches per plant (0.0038), whereas negative indirect effect through umbellets per umbel (-0.0653), seeds per umbel (-0.3912) and test weight (-0.5369).

At phenotypic level, branches per plant showed positive indirect effect on seed yield through umbels per plant (0.0429), days to maturity (0.0329) and days to 50 percent flowering (0.0011), whereas negative indirect effect through umbellets per plant (-0.0027), seeds per umbel (-0.0971), plant height (-0.1057) and test weight (-0.2680). At genotypic level, branches per plant exhibited positive indirect effect through days to maturity (0.0884), whereas negative indirect effect through umbellets per umbel (-0.0009), days to 50 percent flowering (-0.0053), seeds per umbel (-0.0233), umbels per plant (-0.0335), plant height (-0.2032) and test weight (-0.2440).

At phenotypic level, umbels per plant showed positive indirect effect on seed yield through seeds per umbel (0.583), test weight (0.4918), plant height (0.1483), umbellets per umbel (0.0226) and branches per plant (0.004), whereas negative indirect effect through days to maturity (-0.0531) and days to 50 percent flowering (-0.0584). At genotypic level, umbels per plant exhibited positive indirect effect on seed yield through seeds per umbel (0.5986), test weight (0.3399), plant height (0.2936), umbellets per plant (0.1005) and branches per plant (0.0005), whereas negative indirect effect through days to 50 percent flowering (-0.0030) and days to maturity (-0.1209).

At phenotypic level, umbellets per umbel showed positive indirect effect on seed yield through seeds per umbel (0.5871), test weight (0.4859), plant height (0.1475), and branches per plant (0.0056), whereas negative indirect effect through days to maturity (-0.0531), days to 50 percent flowering (-0.0558) and umbels per plant (-0.4956). At genotypic level exhibited positive indirect effect through seeds per umbel (0.6009), test weight (0.3522) and plant height (0.3152), whereas negative indirect effect through branches per plant (-0.0001), days to 50 percent flowering (-

0.0287), days to maturity (-0.1342) and umbels per plant (-0.5747).

At phenotypic level, seeds per umbel showed positive indirect effect on seed yield through test weight (0.4744), plant height (0.1492), umbellets per umbel (0.0226) and branches per plant (0.0077), whereas negative indirect effect through days to maturity (-0.0520), days to 50 percent flowering (-0.0550) and umbels per plant (-0.4907). At genotypic level, it showed positive indirect effect on seed yield through test weight (0.3263), plant height (0.3145) and umbellets per umbel (0.1014), whereas negative indirect effect through branches per plant (-0.0003), days to 50 percent flowering (-0.0280), days to maturity (-0.1272) and umbels per plant (-0.5701).

At phenotypic level, test weight showed positive indirect effect on seed yield through seeds per umbel (0.3590), plant height (0.2083), branches per plant (0.0161), umbellets per umbel (0.0141), whereas negative indirect effect through days to 50 percent flowering (-0.0371), days to maturity (-0.0767) and umbels per plant (-0.3132). At genotypic level, test weight exhibited positive indirect effect through plant height (0.3900), seeds per umbel (0.2948) and umbellets per umbel (0.0530), whereas negative indirect effect through branches per plant (-0.0033), days to 50 percent flowering (-0.0166), days to maturity (-0.2003) and umbels per plant (-0.2925). The residual effect at genotypic level was 0.2266 and at phenotypic level was 0.1911.

The correlation analysis does not provide a clear picture of inter relationship of different characters influencing seed yield. The expression of a complex character like seed yield depends upon the interplay of a number of component characters. According to Falconer (1981) [7], it is often

assumed that association between two characters is evidence of pleiotropy rather than linkage hence under such complex situations, path coefficient analysis is a powerful tool for studying character association. Thus, path analysis was carried out by taking seed yield per plant as dependent variable to partition the correlation coefficient into the measures of direct and indirect effects in order to determine the contribution of different characters towards seed yield.

Path coefficient analysis revealed that test weight, umbellets per umbel, seeds per umbel and umbels per plant exhibited positive direct effect on seed yield per plant. These findings are in accordance with the earlier reports of Yudhvir and Mittal (2003) [6], Sefidan (2014) [5] and Jeeterwal *et al.* (2015) [2]. Contradictory to this Joshi *et al.* (1972) [3] found that the indirect effect of test weight on seed yield per plant were also low.

While plant height, days to maturity, days to 50 percent flowering and branches per plant exhibit negative direct effect on seed yield per plant. Similar results were reported by Srivastava *et al.* (2000) [4] for days to 50 percent flowering, days to maturity and branches per plant, while Agnihotri *et al.* (1997) [1] and Jeeterwal *et al.* (2015) [2] reported positive direct effect for branches per plant and plant height on seed yield per plant.

The residual effect determines how best the causal factors account for the variability of the dependent factor, the seed yield per plant in this case. Its estimate at phenotypic level was low (0.1911) which indicated that the other variables explained about 81% of the variability in the seed yield per plant.

Table 1: Direct (diagonal) and indirect effects (non-diagonal) of different characters on seed yield in fennel at genotypic and phenotypic level

		Days to 50% flowering	Days to maturity	Plant height (cm)	Branches per plant	Umbels per plant	Umbellets per plant	Seeds per umbel	Test weight (g)	Correlation with Seed yield (g)
Days to 50 % flowering	G	0.0351	0.1038	-0.2502	-0.0014	0.5050	-0.0844	-0.4943	-0.3242	-0.5107**
	P	0.0622	0.0515	-0.1435	-0.0009	0.4714	-0.0205	-0.5271	-0.4705	-0.5775**
Days to maturity	G	0.0146	0.2499	-0.4630	0.0033	0.2855	-0.0554	-0.3152	-0.5495	-0.8300**
	P	0.0352	0.0909	-0.2230	-0.0171	0.2932	-0.0134	-0.3413	-0.6652	-0.8409**
Plant height(cm)	G	0.0176	0.2324	-0.4979	0.0038	0.3478	-0.0653	-0.3912	-0.5369	-0.8898**
	P	0.0374	0.0850	-0.2385	-0.0210	0.3121	-0.0142	-0.3732	-0.6884	-0.9007**
Branches per plant	G	-0.0053	0.0884	-0.2032	0.0092	-0.0335	-0.0009	-0.0233	-0.2440	-0.4126**
	P	0.0011	0.0329	-0.1057	-0.0473	0.0429	-0.0027	-0.0971	-0.2680	-0.4438**
Umbels per plant	G	-0.0300	-0.1209	0.2936	0.0005	-0.5897	0.1005	0.5986	0.3399	0.5925**
	P	-0.0584	-0.0531	0.1483	0.0040	-0.502	0.0226	0.5830	0.4918	0.6363**
Umbellets per plant	G	-0.0287	-0.1342	0.3152	-0.0001	-0.5747	0.1031	0.6090	0.3522	0.6419**
	P	-0.0558	-0.0531	0.1475	0.0056	-0.4956	0.0229	0.5871	0.4859	0.6445**
Seeds per umbel	G	-0.0280	-0.1272	0.3145	-0.0003	-0.5701	0.1014	0.6192	0.3263	0.6360**
	P	-0.0550	-0.0520	0.1492	0.0077	-0.4907	0.0226	0.5963	0.4744	0.6526**
Test weight (g)	G	-0.0166	-0.2003	0.3900	-0.0033	-0.2925	0.0530	0.2948	0.6854	0.9106**
	P	-0.0371	-0.0767	0.2083	0.0161	-0.3132	0.0141	0.3590	0.7881	0.9586**

Genotypic Residual effect = 0.2266 *Significant at P = 0.005

Phenotypic Residual effect = 0.1911 ** Significant at P = 0.001

Conclusion

On the basis of the investigation's overall results, it was determined that there was an enormous amount of variance across the fennel germplasm lines for every character, suggesting that there was a lot of scope for fennel cultivar development through selection. Path coefficient analysis at both genotypic and phenotypic level revealed that test weight, umbellets per umbel, seeds per umbel and umbels

per plant were the important characters for selection of high yielding genotypes as they exerted high positive direct effect as well as showed positive correlation with seed yield per plant, while plant height, days to maturity, days to 50 percent flowering and branches per plant exerted direct and negative effect on seed yield per plant. Among the characters the direct effect of test weight was found to be positive and highest indicating that the correlation of test

weight with seed yield was primarily because of the direct effect. In terms of seed yield per plant, 14 of the 216 genotypes outperformed the best check variety RF-125. Based on seed output per plant, several genotypes were found to be promising: UF-4, UF-16, UF-20, UF-23, UF-55, UF-61, UF-79, UF-88, UF-145, UF-149, UF-151, UF-168, UF-172, and UF-189. These superior genotypes can be utilized as donors in breeding programs, and following appropriate testing through multilocal yield studies, farmers may be advised to cultivate these genotypes on a broad scale.

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