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Evaluation on mean performance of yield and its attributing characters in germplasm of fennel (*Foeniculum vulgare* Mill.)

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Abstract

The present study was conducted at the College of Horticulture and Forestry, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya during the rabi season of 2022-23. Plant material consisted of 57 genotypes of fennel including 2 check varieties NDF-1 (A.N.D.U.A.T, Kumarganj, Ayodhya) and RF-101 (SKNAU, Jobner, Rajasthan). The experiment was conducted in Augmented Block Design of 2x1.2m² plot size with 40x60cm² spacing. The assessment covered various characteristics related to both crop productivity and quality. Among the test entries, the wide variations in mean performance of the genotypes were observed for all the characters. Based on mean performance, most of the genotypes were found superior than its best checks for different traits. But some genotype viz., NDF-2 (63.83 g) followed by NDF-46 (56.22 g), NDF-24 (55.65 g), NDF-12 (55.33 g), NDF-9 (55.01g) and other 11 more genotypes were found significantly superior over checks for seed yield per plant along with some other characters.

Keywords: Fennel, marketable yield, medicinal spice

Introduction

Fennel (*Foeniculum vulgare* Mill., 2n=2x=22) is a popular and medicinal seed spice crop that belongs to the Apiaceae (Umbelliferae) family. Its typical commonly used names include sauff (Hindi), Variari (Gujarati), and Badishep (Marathi). It is native to southern Europe and the Mediterranean region, where it has been grown since the beginning of time.

It is one of the most significant seasonal spices and medicinal crops among the spices. Crops classified as allogamous (cross-pollinated) have a cross-pollination rate of 82.2 to 95.40% (Ramanujam *et al.*, 1964) [13]. Compound umbels with a diameter ranging from 5 to 50 cm are produced as terminal flowers. Bisexual, actinomorphic, yellow flowers open in a centripetal direction. The fish string-like leaves can reach a length of 40 cm and are ultimately divided into thread-like sections. The fruit, or schizocarp, has a short stylopodium, lens-shaped pedicel, and colour ranging from pale green to dark brown. A fruit that is fully developed is between 4 and 8 mm long.

Spices are widely utilized to taste and flavour a variety of food preparations as well as in the pharmaceutical, cosmetic, medicine, and perfumery sectors. They also have a distinct aroma and taste. The diuretic qualities and flavourful garnish of the fish-string-like leaves are highly appreciated. About 9.5% protein, 10.0% fat, 42.3% carbs, 18.5% crude fibre, and 13.4% minerals are present in the seeds.

In India, the states that produce the most fennel are Gujarat, Rajasthan, and Uttar Pradesh; several other states, including Bihar, Madhya Pradesh, Punjab, and Haryana, grow it on a smaller scale. Gujarat dominates fennel production, accounting for 80-85% of total production in India. The current fennel cultivation area in India is 90.0 thousand hectares with 157 thousand MT and productivity of 1.575 MT/ha, a significant improvement over previous year (Anonymous., 2022-23) [3].

Fennel is a crop that grows best in cool, dry weather, which encourages high seed output.

The ideal temperature range for growth is between 15 and 20 degrees Celsius; higher temperatures cause early flowering and very poor yield. During the blooming period, the crop is vulnerable to frost damage. Fennel can be planted as an intercrop or mixed crop because it is a long-lasting crop with a modest initial growth. It grows readily in many kinds of soil. September to October is the time for sowing. Numerous culinary customs make use of fennel leaves and seeds. In fennel, not every umbel reaches maturity at the same time. It takes 170–175 days to complete its life cycle.

Materials and methods

The experimental materials for the present investigation were comprised of 57 fennel germplasm stock maintained in the Department of Vegetable Science, CHF, ANDUAT, Kumarganj, Ayodhya. These lines were evaluated in an Augmented Block Design, duration of experimental was December to May, 2023. All the recommended agronomic package of practices and protection measures were followed to raise good crops by Main Experiment Station (MES) of the Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P.) India. The observations were recorded on twelve quantitative traits i.e.; Days to 50% flowering, plant height (cm), number of branches per plant, number of nodes per plant, internodal length(cm), number of umbels per plant, number of umbellets per umbel, number of seeds per umbel, days to maturity, seed weight per umbel (g), test weight and seed yield per plant (g). Each treatment consisted of five rows spaced at 40 cm with plant to plant spacing 60 cm. Each entry was grown in the plot size of 2.0 m × 1.2 m.

Results and Discussion

The mean performance, general means and range of fifty-seven genotypes for 12 characters had been presented in Table.

Days to 50% flowering the duration from days to 50% flowering ranged between 89.30 days (for NDF-33) and 107.80 days (for NDF-44). The average duration for this trait was found to be 98.98 days. Notably, the top-performing genotypes were NDF-33 (89.30 days), followed by NDF-3 and NDF-21 (91.30 days each), NDF-39 (91.80 days), and NDF-9 (92.30 days), all significantly surpassing the general mean and the top-performing check variety, NDF-1 (93.60 days). Similar findings were also reported by Meena *et al.* (2019) [7], and Seet *et al.* (2020) [14].

Plant height (cm) the plant height (cm) was ranged from 103.20 cm (NDF-14) and 149.83 cm (NDF-25) and general mean for Plant height (cm) was 126.69 cm. The top entries among Fifty-seven genotypes were NDF-25 (149.83 cm), NDF-50 (147.16cm), NDF-43 (144.56 cm), NDF-53 (144.20 cm) and NDF-39 (144.11 cm). These genotypes were statistically superior to its general mean and best check NDF-1 (130.43cm). This is in accordance with the finding also reported by Meena *et al.* (2019) [7], Rajput *et al.* (2022) [12].

Number of branches per plant the general mean for number of branches per plant was 6.98 and varied from 4.76 (NDF-5) to

9.36 (NDF-28, NDF-30). Thirty genotypes were significantly higher in branches per plant than the mean and out of Fifty-seven genotypes, the genotypes NDF-28, NDF-30 (9.36), followed by NDF-5 (8.91), NDF-19 (8.56) NDF-24 (8.36) and NDF-13, NDF-26(8.26) were revealed best mean performers than its best check RF-105 (7.14). This is in accordance with the finding also reported by Rajput *et al.* (2022) [12], and Deshwal *et al.* (2023) [14].

Number of umbels per plant the maximum number of umbels per plant was exhibited by NDF-2 (53.51) whereas NDF-49 (35.26) showed minimum number of umbels per plant. The general mean for this trait was 42.78. Out of 57 genotypes, where best was NDF-2(53.51), followed by NDF-12 (48.91), NDF-13(48.61) and NDF-3(47.01) were superior to the best check NDF-1 (44.58) and general mean. This is in accordance with the finding also reported by Meena *et al.* (2019) [7], Rajput *et al.* (2022) [12].

Number of umbellets per umbel the number of umbellets per umbel varied from 17.38(NDF-36) to 41.68 (NDF-24) with general mean 27.32 Best entries were NDF-24 (41.68), followed by NDF-32 (37.78), NDF-9 (36.08), NDF-30 (34.48) were found superior to its best check NDF-1 (29.28) and mean value. Similar results were also reported by Yadav *et al.* (2013) [16], Mohan *et al.* (2017) [9] and Singh *et al.* (2022) [11].

Number of nodes per umbel the range of number of nodes per umbel was from 6.72 (NDF-43) to 12.67 (NDF-4). The general mean for this trait was 9.59. The genotypes NDF-4 (12.67), followed by NDF-11 (12.47), NDF-12 (12.27), NDF-10, NDF-51 (12.07), NDF-34 (11.77) were superior to the best check NDF-1 (9.98) and general mean. Similar results were also reported by Yadav *et al.* (2013) [16], Mohan *et al.* (2017) [9].

Internodal length(cm) Internodal length ranged from 5.70 cm (NDF-14) to 24.01 cm (NDF-50) with general mean value 14.73 cm. best entries were NDF-50 (24.01cm) followed by NDF-28(20.91cm), NDF-44 (20.89 cm), NDF-40 (20.19cm) and NDF-5(19.43 cm) were superior to the than its best check RF-205 (13.95 cm) and general mean value. Similar results were also reported by Jeeterwal *et al.* (2015) [5], Patel and Patel (2015) [10], Meena and Dhakar (2017) [6] and Singh *et al.* (2020) [14].

Number of Seeds per umbellet Number of seeds per umbellet ranged from 17.58 (NDF-29) to 33.88 (NDF-6) with average value 25.60, Out of Fifty-seven genotypes, best entries NDF-6 (33.88) followed by NDF-17 (33.18), NDF-20 (32.78) and NDF-18, NDF-23 (32.58) observed maximum number of Seeds per umbel than its best check RF-105 (28.50) and general mean value. Similar results were also reported by Jeeterwal *et al.* (2015) [5], Patel and Patel (2015) [10], Meena and Dhakar (2017) [6]. Days to maturity A large amount of variability was found for days to maturity which varied from 156.90 Days (NDF-26, NDF-34) to 178.40 Days (NDF-43) with the general mean of 168.01 days. Out of Fifty-seven genotypes, best entries NDF-26, NDF-34 (156.90) followed by NDF-30 (157.90), NDF-21 (158.90) and NDF-10 (159.40) were significantly lower than its general mean and best check RF 101 (166.40) for days to maturity. Similar findings were also reported by Meena *et al.* (2019) [7], and Seet *et al.* (2020) [14].

Table 1: Mean performance of Fifty-seven genotypes for twelve characters in fennel

Characters	Days of 50% flowering	Plant hight(cm)	Number of branches per plant	Number of umbel per Plant	Number of umbellet per Plant	Number of node per Plant	Internodal length(cm)	Number of grain per umbellet	Days to maturity	Weight of grain per umbel(g)	1000 Seed weight(g)	Seed yield/ Plant(g)		
NDF-2	101.30	109.25	7.16	53.51	31.48	10.47	16.34	29.48	175.40	1.19	8.94	63.83		
NDF-3	91.30	122.55	6.56	47.01	26.08	10.27	14.42	27.88	173.40	1.09	8.15	51.32		
NDF-4	104.30	117.75	4.96	42.06	19.28	12.67	13.22	24.48	168.40	0.73	8.16	31.64		
NDF-5	103.30	125.75	4.76	42.41	32.08	10.99	19.43	29.28	165.40	1.13	8.84	47.60		
NDF-6	101.30	133.55	6.66	45.81	27.48	10.07	16.11	33.88	172.40	1.16	7.82	52.92		
NDF-7	103.30	128.15	6.16	42.01	30.68	9.67	18.64	21.88	168.40	1.05	8.62	44.02		
NDF-8	100.30	132.35	5.89	45.41	30.08	10.27	12.59	23.68	177.40	1.13	8.36	51.17		
NDF-9	92.30	113.95	5.56	46.81	36.08	10.67	12.79	26.88	164.40	1.18	7.28	55.01		
NDF-10	105.30	110.75	5.56	43.21	21.08	12.07	9.76	22.78	159.40	0.77	7.71	34.15		
NDF-11	102.30	117.15	7.66	46.21	30.48	12.47	17.54	24.88	162.40	1.17	7.37	53.84		
NDF-12	96.30	110.95	6.56	48.91	32.28	12.27	10.53	25.88	171.40	1.13	7.59	55.33		
NDF-13	104.30	108.34	8.26	48.61	29.68	9.37	13.96	28.98	174.90	0.83	8.99	40.88		
NDF-14	99.30	103.20	6.96	38.81	24.68	9.77	5.70	30.38	167.90	0.98	6.61	37.30		
NDF-15	95.30	139.66	6.76	46.01	26.28	7.57	15.44	20.38	165.90	0.69	8.70	32.16		
NDF-16	101.30	126.30	7.36	44.61	34.28	9.17	8.43	28.98	172.90	1.14	8.63	50.57		
NDF-17	93.30	130.46	6.56	42.21	27.68	7.97	13.50	33.18	169.90	1.13	7.69	47.16		
NDF-18	99.30	122.70	6.96	39.41	24.48	9.97	11.00	32.58	161.90	1.09	8.38	42.16		
NDF-19	98.30	120.48	8.56	43.61	22.88	9.37	13.44	21.98	162.90	0.62	7.56	27.27		
NDF-20	96.30	137.70	7.76	45.41	27.28	7.77	14.77	32.78	170.90	1.13	7.52	51.13		
NDF-21			91.30	124.52	7.16	41.01	25.28	6.97	14.83	31.58	158.90	0.95	6.88	38.51
NDF-22			100.30	129.94	7.76	43.01	23.48	8.97	7.58	30.78	171.90	0.93	7.78	39.79
NDF-23			97.30	135.74	7.84	46.61	33.08	7.97	14.13	32.58	163.90	1.07	8.20	49.89
NDF-24			98.30	118.23	8.36	43.91	41.68	9.17	14.58	30.68	168.90	1.27	7.34	55.65
NDF-25			107.30	149.83	7.96	39.31	29.48	9.97	13.79	27.48	164.90	1.14	8.34	45.13
NDF-26			95.30	128.55	8.26	41.91	29.88	8.37	17.54	24.88	156.90	1.01	7.93	42.50
NDF-27			97.30	130.79	6.96	41.21	31.48	10.37	17.84	22.08	160.90	0.95	7.54	39.41
NDF-28			94.30	134.83	9.36	44.11	23.88	10.47	20.91	22.48	171.90	0.95	7.14	41.93
NDF-29			101.30	113.63	5.46	44.71	28.08	8.17	14.02	17.58	171.90	0.76	7.66	34.06
NDF-30			105.30	138.58	9.36	43.71	34.48	9.77	17.93	19.88	157.90	0.94	7.94	41.15
NDF-31			97.30	132.73	7.96	39.11	31.68	9.77	13.71	19.08	163.90	0.91	7.84	36.04
NDF-32			99.30	129.63	7.16	44.11	37.48	10.97	11.95	19.08	170.90	1.04	8.74	45.86
NDF-33			89.30	137.83	6.16	45.31	28.88	10.77	17.84	21.58	162.90	0.94	6.72	42.53
NDF-34			96.30	117.73	7.36	43.31	31.88	11.77	10.14	27.08	156.90	1.24	7.52	53.65
NDF-35			101.80	116.72	6.91	40.01	22.38	7.92	18.38	22.68	176.40	0.85	5.52	33.77
NDF-36			97.80	104.20	5.01	43.21	17.38	8.32	17.87	28.08	163.40	0.75	4.60	31.68
NDF-37			105.80	129.08	6.41	41.81	20.38	9.22	19.17	21.68	169.40	0.79	5.61	32.51
NDF-38			93.80	110.31	5.61	39.11	26.18	8.92	17.56	31.88	173.40	1.27	6.75	50.58

NDF-39	91.80	144.11	5.31	39.81	26.78	8.72	20.19	30.48	164.40	1.32	4.92	53.54
NDF-40	103.80	115.92	6.31	38.41	27.38	10.92	12.54	32.28	167.40	1.24	5.07	48.51
NDF-41	101.80	121.80	8.01	42.61	20.98	9.52	15.17	24.08	174.40	0.75	4.59	31.28
NDF-42	96.80	136.16	6.11	36.91	20.78	8.72	15.21	26.68	173.40	0.94	5.57	34.91
NDF-43	100.80	144.56	7.01	43.01	23.58	6.72	18.51	22.28	178.40	0.97	6.82	41.58
NDF-44	107.80	143.24	6.31	42.01	20.18	7.32	20.89	24.68	168.40	0.80	6.37	33.10
NDF-45	98.80	135.30	6.91	43.61	17.78	6.92	18.81	23.78	166.40	0.75	7.12	31.96
NDF-46	96.30	128.00	6.61	44.46	33.18	9.14	12.51	23.18	160.40	1.26	7.13	56.22
NDF-47	91.30	130.60	7.21	38.16	26.18	8.76	12.79	20.38	170.40	0.85	7.83	31.81
NDF-48	102.30	125.84	8.01	42.46	22.18	8.27	17.12	18.78	172.40	0.71	7.08	29.10
NDF-49	104.30	122.65	5.71	35.26	26.78	10.07	11.37	24.38	166.40	1.09	8.48	38.42
NDF-50	99.30	147.16	6.21	40.16	24.98	10.47	24.01	26.18	175.40	1.09	7.13	43.67
NDF-51	102.30	129.20	8.91	38.46	24.78	12.07	9.72	22.78	176.40	0.91	7.65	34.50
NDF-52	100.30	115.00	7.11	38.66	24.38	10.77	10.57	19.18	163.40	0.82	6.64	30.99
NDF-53	97.30	144.20	6.91	40.06	30.58	9.60	15.77	23.78	176.40	1.23	8.09	49.49
NDF-54	98.30	132.85	6.21	44.16	24.18	9.92	14.05	23.88	166.40	0.93	6.88	40.51
NDF-55	96.30	117.75	5.81	43.56	25.28	8.84	10.13	23.98	168.40	0.86	7.19	36.75
NDF-56	100.30	136.95	6.41	41.56	27.18	9.37	15.30	21.68	163.40	0.89	7.53	36.38
NDF-1 (Check)	93.60	130.43	6.78	44.58	29.28	9.98	13.87	27.06	167.40	1.08	7.61	47.84
RF-101 (Check)	100.00	125.77	7.14	43.24	29.28	9.76	13.95	28.50	166.40	1.04	7.36	44.78
Mean	98.98	126.69	6.89	42.78	27.32	9.59	14.73	25.60	168.01	0.99	7.37	42.45
CV (%)	0.96	1.47	5.47	4.29	5.52	10.51	21.08	7.52	1.64	3.18	6.61	5.05
SED	0.87	1.18	0.24	1.16	0.95	0.64	1.96	1.22	2.22	0.02	0.31	1.35
CD	2.42	3.28	0.66	3.22	2.65	1.77	5.45	3.38	6.15	0.06	0.85	3.76
Max	107.80	149.83	9.36	53.51	41.68	12.67	24.01	33.88	178.40	1.32	8.99	63.83
Min	92.30	103.20	4.76	35.26	17.38	6.72	5.70	17.58	156.90	0.62	4.59	27.27

Seed weight per umbel (g) The performance analysis of various genotypes showed that seed weight per umbel ranged from 0.62 g (observed in NDF-19) to 1.32 g (seen in NDF-39), with an average seed weight per umbel of 0.99 g. Among all fifty-seven genotypes assessed, NDF-39 exhibited the highest seed weight per umbel at 1.32 g, followed by NDF-24 and NDF-38 at 1.27 g each, NDF-46 at 1.26 g, and NDF-34 and NDF-40 at 1.24 g each. These values exceeded both the performance of the top check variety, NDF-1 (1.08 g), and the overall mean. Similar results were also reported by Jeeterwal *et al.* (2015; Patel and Patel (2015)^[5, 10], Meena and Dhakar (2017)^[6] and Singh *et al.* (2020)^[14].

Test weight (g) Test weight varied between 4.59 g (NDF-41) and 8.99 g (NDF-13), with an average of 7.37 g across all genotypes. Out of fifty-seven genotypes, NDF-13 exhibited the highest test weight at 8.99 g, followed by NDF-2 (8.94 g), NDF-5 (8.84 g), NDF-32 (8.74 g), NDF-15 (8.70 g), and NDF-7 (8.62 g), surpassing the best check variety, NDF-1 (7.61 g), and the mean value. Similar results were also reported by Yadav *et al.* (2013)^[16], Mohan *et al.* (2017)^[9] and Singh *et al.* (2020)^[14].

Seed yield per plant (g) The seed yield per plant (g) ranged from 27.27g (NDF-19) to 63.83g (NDF-2), with an average of 42.45 g. Among the 57 genotypes (including checks), most outperformed the best check, NDF-1 (47.84 g). Notably, NDF-2 (63.83 g), NDF-46 (56.22 g), NDF-24 (55.65 g), NDF-12 (55.33 g), and NDF-9 (55.01g) demonstrated significantly higher yields compared to NDF-1 (47.84 g) and the mean value. This is in accordance with the finding also reported by Meena *et al.* (2019)^[7], Rajput *et al.* (2022)^[12], and Deshwal *et al.*, (2023)^[4].

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Conclusion

Fennel (*Foeniculum vulgare* Mill.) is a popular and medicinal seed spice crop that belongs to the Apiaceae (Umbelliferae) family. The present investigation was undertaken to evaluate 57 genotypes of fennel for horticultural traits. The wide variations in mean performance, most of the genotypes were found superior than its best checks for different traits. But some genotype viz., NDF-2 (63.83 g) followed by NDF-46 (56.22 g), NDF-24 (55.65 g), NDF-12 (55.33 g), NDF-9 (55.01g) and other 11 more genotypes were found significantly superior over checks for seed yield per plant along with some other characters. It can be concluded that, as a wide range of variation for almost all the economically important traits was present in this crop, so there is a vast scope for improvement through different breeding procedure.

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