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Ajmer Fennel-3: A high Yielding and *Ramularia* Blight Resistant Fennel Variety

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Abstract

A new fennel variety AF-3 has been released with an average seed yield (2143 kg ha⁻¹), essential oil (1.9%) and *Ramularia* blight resistance. The variety was recommended for release in Annual Group Meet XXIX AICRPs workshop held at Dr. YS Parmar University of Horticulture & Forestry, Solan (H.P.) during 4-6th Oct., 2018 and notified vide S.O.4272(E) dated 26.11.2019 for commercial cultivation under timely sown, with recommended POP for growing areas of Rajasthan. Adoption of new fennel variety AF-3 by the fennel growers will increase their farm productivity and income, thus improving their livelihood besides better sustenance of spice industry in the country.

Keywords: AF-3, high yielding, essential oil, Moderately Resistant to *Ramularia* Blight

Introduction

Fennel (*Foeniculum vulgare* Mill) is a short-lived perennial with some types hardy crop, cultivates best as an annual in winter climates. Leaves are smooth, dark green in colour and finely dissected with very narrow lobes, giving a feathery appearance to the foliage. Plant bears small, bright yellow flower on terminal compound umbels at the top of the stems. Fruits are oblong to ovoid with 0.12–0.2 inches (3–5 mm) long and 1.5–2.0 mm broad. Fennel seeds diverge from three to five lines in length and are elliptical, slightly curved, and somewhat obtuse at the ends. It is originated in the Southern Mediterranean region and it grows wild throughout the Northern, Eastern, and Western hemispheres, specifically in Asia, North America, and Europe (Badgujar *et al.*, 2014). In India, fennel is mainly growing in Gujarat, Rajasthan, Madhya Pradesh, Haryana, Punjab, Uttar Pradesh and few other states, however, it was cultivated in almost every country (Muckensturm *et al.*, 1997). Fennel crop is covering an area of 64.92 thousand ha with an annual production of 114.97 thousand tonnes in 2021-22 (DASD, 2023). The annual crop productivity of fennel is 1771 kg ha⁻¹, and it is possible to enhance its productivity through improved breeding technique. Fennel is a cool

season crop, mainly grown during winter season in north India, and does not flourish in southern part of the country except at higher elevation (Mehta *et al.*, 2009). A dry and cold weather support higher seed production. Fennel flourishes in long sunny days. A temperature range of 15-30°C is optimum and above 25°C for extended period usually retards development of fennel and in early growth may result premature flowering and very low seed yield. Crop is susceptible to frost injury at flowering stage. The optimum temperature for seed germination is 20-29°C. High winds at the time of maturity can cause shattering of seed and very hot winds at flowering reduce seed setting. Therefore, climatic conditions are important abiotic factors, which decide expression of genetic potentiality off particular genotype. It is a medicinal plant belongs to the Apiaceae family and used by humans since ancient times, due to its flavour. Fennel seeds have a special kind of fragrance and a pleasant aromatic taste. They are widely used in various food preparation, pickles, soups, sauces, candies, pastries, liquors, bakery items and many more (Tamboli *et al.*, 2020). Leaves and seeds are digestive, used for remedies of cough, colic, flatulence, thirst, constipation, diarrhoea and dysentery (Randhawa *et al.*, 1978).

Biotic and abiotic stresses along with several management practices play a crucial role in minimization of yield and quality. Like other seed spice crops, fennel is also attacked by many fungal diseases (Mukerji and Basin, 1986). *Ramularia* blight caused by *Ramularia foeniculi* Sibilla is one of most important disease and cause considerable damage to the quality and quantity of seeds (Aliya *et al.*, 2017; Jaiman *et al.*, 2013). The several management practices using chemical pesticides can reduce the disease incidence at some extent, however, the use of chemical pesticides generate its residue in the produce, which acts as a trade barrier in the export market. ICAR-NRCSS is maintaining 376 fennel germplasm lines in its repository having wide range of characteristics for yield, quality and resistant source for different biotic stresses. In view of such circumstances, there is a need to formulate a breeding programme for development of fennel variety showing higher yield characters and resistance to *Ramularia* blight disease by evaluating of fennel germplasm.

Materials and Methods

Evaluation and testing of advance fennel lines

Fennel germplasm lines were evaluated at the Research Farm of ICAR-National Research Centre on Seed Spices, Ajmer (Rajasthan) during winter season for three successive years 2012-13, 2013-14 and 2014-15 for higher yield potential, quality and *Ramularia* disease resistance. The trials were laid out in randomized block division (RBD) keeping standard crop geometry: line to line and plant to plant distance 50 x 25 cm. The experimental site is located between 74° 36' 01" E longitude and 26° 22' 31" N latitude at an altitude of 486 m above mean sea level (Meena *et al.*, 2019). The soil of experimental plots was sandy loam in texture, pH 7.2, EC 0.3, well drained, low in organic carbon and available nitrogen, medium in available phosphorus and potash content. The crop was fertilized with a recommended dose of fertilizer *i.e.* 90 kg N and 40 kg P₂O₅ and 25 kg K₂O in addition to 5-10 tonnes per hectare FYM. Observations for ancillary data on 50% flowering, plant height (cm), No. of branches per plant, umbels per plant, umbellate per umbel, seed per umbel, test weight (g) and days to maturity were recorded by adopting standard procedure. Advanced lines were selected and further evaluated under coordinated varietal trials at eight different locations [CVT, Ajmer (Rajasthan), Hisar (Haryana), Jobner (Rajasthan), Dholi (Bihar), Jabalpur (Madhya Pradesh), Kumarganj (Uttar Pradesh), Pantnagar (Uttarakhand), and Jagudan (Gujarat)] for three consecutive years 2015-16, 2016-17 and 2017-18. Yearly cumulative data of all eight locations were presented in All India Coordinated Research Project on Spices (AICRPs) for performance of the lines. The data were analysed following standard statistical procedures using statistical software OPSTAT developed by Chaudhary Charan Singh Haryana Agricultural University, Hisar. The essential oil was extracted from 30g dried fennel seed using hydro-distillation method (Kapas *et al.*, 2011).

Pedigree: Fennel variety AF-3 has been developed from the germplasm material collected from Tonk district of Rajasthan. Recurrent selection of breeding method was adopted. This variety was tested under AICRP on Spices using codes AF-206 code FNL-82, Based on its performance over the years and locations,

the advanced entry AF-206 code FNL-82 has been recommended for release (through virtual mode) in the Annual Group Meet XXIX AICRPS workshop held during 4-6th October, 2018 at Dr. YS Parmar University of Horticulture & Forestry, Solan (H.P.). Subsequently, advanced entry FNL-82 was released and notified as variety in the name of Ajmer Fennel-3 by the Central Suj-Committee on Crop Standards Notification and Release of Varieties for Horticultural Crops, Ministry of Agriculture, Department of Agriculture and Co-operation, Government of India, New Delhi vide Gazette Notification S.O.No./4272 (E); dated 26.11.2019.

Varietal description

Plants are annual herb, semi-erect, branched, dense foliage (fully bloom leaf foliage), medium sized plant about 160 cm in height, king umbel base leaf is straight, king umbel leaf have petiole and short 1st inter-node, seeds are medium bold, ecliptic in shape. Variety fall in medium group of maturity, takes 175 to 180 days. The variety shows moderately resistance for *Ramularia* blight and less infested with aphids as compared check varieties.

Yield performance

Initial evaluation trials:

Initial evaluation (station) trials were conducted at research farm of ICAR- National Research Centre on Seed Spices, Ajmer (Rajasthan) during 202012-13 to

2014-15, wherein proposed entry AF-206 performed best over rest of the entries/germplasm lines, produced 29.21, 28.70 and 30.3 quintal per hectare seed yield in 2012-13, 2013-14 and 2014-15, respectively (Table 1). The advanced entry AF-206 recorded 12.6 per cent increased seed yield over national check RF-101 and 9.95 per cent increased seed yield over national check RF-205.

Multi-location testing: Under All India Coordinated Research Project (AICRP) on Spices, the advanced entry AF-206 code FNL-82 was performed better as compared to other entries treated as control along with national checks. Three years pooled data of seed yield for each evaluating centre are presented in table 2, revealed that the seed yield of proposed entry AF-206 was found higher side at Jagudan (47.22 q ha⁻¹) followed by Ajmer (22.71 q ha⁻¹), Pantnagar (22.47q ha⁻¹) and Jobner (21.29 q ha⁻¹), however, few entries yield was slightly higher but statistically at par with AF-206.

Quality Performance

The essential oil content in the variety was considered as quality parameter for the release, henceforth, essential oil was extracted from the dried seed of fennel every year using hydro-distillation method. Three years cumulative data of essential oil are presented in table 3, revealed that the proposed advanced entry AF-3 code FNL-82 contained 1.9% essential oil, which was 18.5

Table 1. Seed yield (kg ha⁻¹) of fennel varieties in station (pooled mean of 2012-13 to 2014-15) and multi-location trials (pooled mean of 2015-16 and 2017-18)

Locations	Seed yield (kg ha ⁻¹) of varieties		
	AF-206	RF-101	RF-205
SFT, Ajmer	29.40	NA	NA
Ajmer (Rajasthan)	22.71	16.78	19.85
Hisar (Haryana)	18.00	16.22	16.47
Jobner (Rajasthan)	21.29	21.18	23.08
Dholi (Bihar)	7.45	9.78	11.17
Jabalpur (MP)	11.55	8.42	9.86
Kumarganj (UP)	12.79	11.31	11.97
Pantnagar, UK	22.47	21.74	18.27
Jagudan (Gujarat)	47.22	46.85	45.28
Mean	21.43	19.03	19.49
Percent increase in yield over national check RF 101		12.6	
Percent increase in yield over national check RF 205			9.95

Table 2. Seed yield (q ha^{-1}) of fennel varieties in coordinated trial at different locations across the country during 2015-16 to 2017-18

Entries/ varieties	Code	Locations							
		Hisar	Jobner	Dholi	Jabalpur	Kumarganj	Ajmer	Pantnagar	Jagudan
AF-206	FNL-82	18.00	21.29	19.65	11.55	12.79	22.71	22.47	47.22
JF-576	FNL-77	18.07	21.02	19.55	10.16	12.08	20.24	17.52	47.25
JF-2012-9	FNL-78	16.67	18.33	17.50	8.95	11.66	18.97	19.41	35.82
UF-290	FNL-79	17.89	20.98	19.44	9.72	12.75	23.69	20.18	48.66
UF-291	FNL-80	17.89	22.73	20.31	8.94	12.10	20.47	20.45	36.72
AF-205	FNL-81	16.54	18.31	17.42	11.53	12.87	22.70	19.40	30.20
NDF-51	FNL-83	19.26	14.82	17.04	10.92	11.59	15.78	19.69	22.99
NDF-67	FNL-84	20.25	17.20	18.73	11.34	13.98	17.63	19.07	20.41
HF-151	FNL-85	19.23	17.40	18.32	7.60	12.82	21.18	19.84	29.39
HF-212	FNL-86	19.25	17.15	18.20	7.42	14.86	18.76	20.53	24.65
RF-15	FNL-87	19.02	13.57	16.30	9.75	10.90	10.88	22.21	25.81
RF-68	FNL-88	17.88	13.38	15.63	7.03	11.36	7.75	21.85	30.95
PF-1	FNL-89	18.55	2.10	10.32	5.36	9.03	5.85	22.80	29.81
RF-101	RF-101	16.22	21.18	18.70	8.42	11.31	16.78	21.74	46.85
RF-205	RF-205	16.47	23.08	19.78	9.86	11.97	19.85	18.27	45.28
CD ($p=0.05$)		0.55	2.67	1.47	2.18	0.64	0.59	2.44	2.21
CV (%)		7.25	8.77	7.93	13.19	2.29	1.63	12.75	10.56

per cent higher than national check RF-205 (1.6%) and 11.7% higher than national check RF-101

Tolerance to disease resistance

The new variety Ajmer Fennel-3 code FNL-82 possess moderately resistance to Ramularia blight, which causes severe yield loss in fennel. Percent disease index showed that AJ-FNL-3 received lower disease incidence as compared to National checks RF-101 and RF-205 (Table 4). Based on three years pooled data, 22.3% PDI recorded in proposed variety against 26 and 29.3% PDI recorded on national checks RF-101 and RF-205.

Compounds of essential oil

The major constituent of essential oil of fennel variety AF-3 is Anethol + Estyragol (45) which was higher to national check RF-205 (Table 5) and Geraniol contained highest (1.13) over both the check varieties. The other compounds contained are Alpha Pinene (5.30), Camphane, Beta Pinene (0.262), Myrcene (0.457), Cymene (0.098), Gama terpenes, 4-allyl Anisole (36.90) and Geranyl acetate (0.13).

Agronomic Management

Planting time: The suitable planting time for the Variety AF-3 was 11-21 October which is 10-15 days later than the sowing time of commonly used fennel varieties.

Planting: Seed rate: 8-10 kg ha^{-1} , variety AF-3 was sown in winter season at crop geometry of 60 cm x 40 cm (row to row and plant to plant distance) provided the highest plant growth and seed yield.

Manures and Fertilizer: Apply 10-15 t ha^{-1} FYM at the time of soil preparation before seed sowing. In addition to FYM, fertilizer doses of 90:40:30 kg ha^{-1} nitrogen, phosphorus and potassium, respectively, where half dose of N and full dose of P_2O_5 and K_2O is applied at the time of seed sowing. The remaining half dose of N is given at 35-40 days after sowing as top dressing. Nutrient management should be done as per soil analysis data and regional recommendations for optimum productivity of this variety.

Irrigations: Irrigation is one of the most important crop inputs for higher quality production of fennel crop. In fennel variety AF-3, three different irrigation methods

Table 3. Essential oil (%) content in seed of the proposed variety tested at NRCSS, Ajmer (Rabi 2012-13 to 2014-15)

S No.	Name of entries	Essential oil %	% higher than RF-205	% higher than RF-101
1.	AF-3 (FNL-82) (Proposed entry)	1.9	18.5	11.7
2.	RF-205	1.6		
3.	RF-101	1.7		

Table 4. Performance of proposed genotypes against *Ramularia* blight disease in CVT at NRCSS, Ajmer (pooled of 2015-16 to 2017-18)

S. No.	Name of entries	2015-16	2016-17	2017-18	PDI (%)
1	AF-3 (Proposed entry)	21	18	28	22.3
2	RF-101	29	27	22	26.0
3	RF-205	32	29	27	29.3

Table 5. Profiling of essential oil of the proposed variety tested at NRCSS, Ajmer in CVT during 2014-15

Compounds in essential oil	AF-3 (FNL-82)	RF-205	RF-101
Alpha Pinene	5.30	3.86	5.50
Camphene	0.094	0.05	0.10
Beta Pinene	0.262	0.27	0.24
Myrecene	0.457	0.38	0.31
Cymene/Cymol	0.098	0.10	0.08
Gama Terpinene	9.74	8.69	7.86
4-allyl Anisole	36.90	48.41	20.05
Geraniol	1.13	0.50	0.95
Anethol + Estyragol	45.00	37.46	64.54
Geranyl Acetate	0.13	0.25	0.32

i.e. Micro Sprinkler, Drip and Surface irrigation are recommended. For this AF-3 variety, 6-8 irrigations are sufficient depending on soil type and climatic condition for traditional cultivation, where irrigation is given by drip method the IW/CPE ratio 1.0 was found best over rest of the procedures.

Plant protection measures: Aphid, jassids, thrips, seed wasps, *Ramularia* blight, are the major insect-pests and diseases of fennel right from seed germination to maturity of crop. For the management of aphids, jassids, thrips, apply one of the acetamiprid

70SP @ 0.3g/lit. or imidacloprid 17.8 SL @ 0.3ml/lit. or thiamethoxam 25WG 0.2g/lit of water. For the control of *Ramularia* blight, apply mancozeb (75%WP) @ 2g/lit of water as foliar application during initiation of disease.

Adaptability: AF-3 (FNL-82) has been performed well in initial evaluation trials at Ajmer (semi-arid region of Rajasthan), Jobner, Jaipur (Rajasthan) and multi-location trials conducted under AICRP in all major fennel growing region of the country. Hence, it has been recommended for cultivation in Gujarat, Rajasthan, Haryana, Madhya Pradesh, Andra

Pradesh, Bihar, Uttar Pradesh and other fennel growing states of India.

Conflicts of Interest: The authors declare no conflicts of interest.

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