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Effect of geometry and fertilizer levels on growth and yield of fennel (*Foeniculum vulgare* Mill.) under northern dry zone of Karnataka

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Abstract
An experiment was carried out on effect of geometry and fertilizer levels on growth and yield of fennel (*Foeniculum vulgare* Mill.) under northern dry zone of Karnataka during *rabi* 2019-20 at department of Plantation, Spices, Medicinal and Aromatic crops, College of Horticulture, Bagalkot. The experiment was laid out in split plot design with three replications consisting of 3 levels of spacing (S_1: 60 × 20 cm, S_2: 60 × 30 cm and S_3: 60 × 40 cm) as main plot and 3 levels of fertilizer (F_1: 80:30:20, F_2: 90:40:30 and F_3: 100:50:40 NPK kg ha^{-1} with 15 t FYM ha^{-1}) as sub plot with 9 treatment combinations. Among various spacing levels, 60 x 30 cm spacing has recorded highest seed yield (1234.12 g per plot) and (1714.06 kg ha^{-1}). Application of F_2 (90:40:30 N, P_2O_5, K_2O kg ha^{-1}) was found economical has it recorded higher seed yield of (1212.46 g plot^{-1}) and (1683.99 kg ha^{-1}).

Keywords: Fennel, *Foeniculum vulgare* Mill. Growth, yield, fertilizer, spacing

Introduction
Spices are high value and low volume commodities of commerce in the world market. India is known as the home of spices and has consistently been the major player in production, consumption and export of spices. The fast growing food industries world over depends largely on spices as taste and flavour makers to create variation in their product line. Spices comprise fragrant products of plant origin used for flavouring food and beverages. Spices are gold mine of natural bioactive compounds, enhance the keeping quality and medicinal values of food. Spices in India are covered over an area of 45,17,720 ha with production of 1,04,85,100 tonnes (Anon., 2020) [2].

Fennel (*Foeniculum vulgare* Mill.) 2n=22, belongs to the family *Apiaceae*. It is native of Southern Europe and Mediterranean region. It is one of the four most important seed spice cultivated throughout the temperate and sub-tropical regions of the world in the countries like Romania, Russia, Germany, France, Italy, India, Japan, Argentia and The U.S.A.

In India, fennel is mainly cultivated in states of Gujarat, Rajasthan, Bihar, Punjab, Haryana, Karnataka, Uttar Pradesh and Madhya Pradesh. Gujarat is the major fennel producing state with an area of 42,038 ha with annual production of 87,435 tonnes (Anon., 2020) [2].

In Karnataka, fennel is mainly cultivated in districts of Bangaluru, Gadag, Mysuru, Chikkaballapura, Ramanagara and Mandya. Covering total area of 35 ha with production of 79 tonnes (Anon., 2018) [1].

Fennel is a stout glabrous aromatic herb grows up to height of 100-180 cm. Stem is cylindrical, smooth and hallow at maturity. Leaves are alternate, pinnately compound with partial leaf blades and sheathed petiole. Inflorescence is terminally born compound umbel with golden yellow coloured flowers. The number of umbels plant^{-1} varies widely depending upon the variety and agronomic conditions normally it varies from 11-30. Each umbel bears 4-22 umbellets and 4-7 florets per umbellet. Fruit commonly known as seed, is a schizocarp. A fully grown fruit is 4-10 mm long. Normally fruits are light greenish to yellow in colour, slightly curved obtuse at the ends with five prominent ridges. The fruit has stylopodium and pericarp with oil canals contain an essential oil. The seed contains 0.7-1.2% volatile oil (Badgujar *et al*. 2014) [3].

Root is regarded as purgative. The fruits (seeds) are used as stimulant, carminative and in the cure of colic pains. Seeds have potential use in treatment of glaucoma, as a diuretic and

potential drug for the treatment of hypertension. Fennel also has galactagogue properties due to presence of phytoestrogens, antioxidant activity, hepatoprotective, hypoglycemic, chemopreventive, antiflatulent, antispasmodic and estrogenic activities. Fennel provided an excellent source of potassium, calcium, magnesium, iron, phosphorous and zinc (Badgujar *et al*. 2014) [3].

Planting geometry determines the efficiency of moisture and nutrients utilized by plants as well as interception of incident solar radiation. Very high plant population may cause adverse effect on crop in terms of competition among plants for nutrient and moisture, while low plant population may not take full advantage of applied nutrients and allow weeds to grow resulting in low production. Thus maintaining optimum plant population is a primary requirement to get higher yield (Dubey and Lal, 1971) [5].

The major nutrients especially Nitrogen, Phosphorous and Potassium play important role in plant growth and development. Adequate supply of N promotes higher photosynthetic activity and vigorous vegetative growth and as a result, the plants turn into dark green colour Phosphorus imparts hardness to shoot, improves grain quality, regulates photosynthesis, governs physiochemical processes and help in the enlargement of cell, develop resistant to diseases and fixation of phosphorus. Potassium is known to increase the resistance of plants to the moisture stress, heat and diseases caused by fungi, nematodes and other microorganisms. There is wide scope to improve and increase the fennel production and productivity by enhancing its nutritional requirement (Balasubramaniyam and palaniappan, 2005) [4].

Productivity of fennel has remained low when compared to its potential yield of 2500 kg ha^{-1}. So the efforts have been made to enhance the productivity of the fennel by adopting suitable agronomic practices such as altering plant population and management of nutritional status of the soil. Proper fertilization and optimum spacing are the most important factors for getting higher yields. In view of the importance of these factors, present investigation was conducted to study the effect of geometry and fertilizer levels on growth and yield of fennel.

Material and Methods

The present research was conducted during *rabi* season of 2020-2021 at College of Horticulture, University of Horticultural Sciences, Bagalkot. The experimental site was situated at 16º 10' North latitude, 74º 42' East longitudes and at an altitude of 542.0 m above the mean sea level (MSL). This domain falls under the Northern dry zone of Karnataka (*Zone*-3). The experiment was delineated in a split plot design with spacing in main plot and fertilizer levels in sub plot replicated thrice with nine treatment combinations. The treatments consist of three spacing levels (S) – S_1: 60 x 20 cm, S_2: 60 x 30 cm and S_3: 60 x 40 cm and three fertilizer levels (F) – F_1: 80:30:20 N, P_2O_5, K_2O kg ha^{-1}, F_2: 90:40:30 N, P_2O_5, K_2O kg ha^{-1} and F_3: 100:50:40 N, P_2O_5, K_2O kg ha^{-1} with 15 t FYM ha^{-1}. Nitrogen was applied in three split doses in concerned treatments. Half dose of nitrogen and full dose of phosphorus and potassium were applied as basal dose and remaining half dose of nitrogen applied as top dressing at 30 and 60 DAS. Variety used was Ajmer fennel-1. Five plants were selected at random and labelled in each plot for recording observations on growth and yield parameters. Further, statistical analysis of the data was carried out as per the method suggested.

Results and Discussion

Effect of geometry and fertilizer levels on growth parameters of fennel

The data on plant height, number of primary branches, fresh weight of seed and stover and dry weight of seed and stover at harvest are presented in Table 1. The maximum plant height (169.97 cm) was recorded with planting geometry of 60 x 20 cm at harvest. The minimum plant height (156.41 cm) was recorded under S_3 (60 x 40 cm) spacing at harvest. The observed crop behaviour at closer spacing is similar with Donald (1963) findings, according to which plants extend rapidly due to mutual shading up to a certain population level, but beyond that, elongation is inhibited due to limited availability of photosynthates. The maximum number of primary branches per plant (11.97) at harvest was recorded in planting geometry of 60 x 40 cm and it was *on par* with 60 x 30 cm (11.72). The maximum fresh and dry weight of seed (59.52 g and 40.65 g) and stover (201.13 g and 68.14 g) at harvest were found maximum in plants spaced at wider spacing of 60 x 40 cm. The minimum number of primary branches per plant (11.15), The minimum fresh and dry weight of seed (33.58 g and 19.50 g) and stover (102.85 g and 33.51 g) was noticed in S_1 *i.e.* 60 x 20 cm at harvest. Increased spacing or reduction in plant population per unit area has resulted in significant increase in the number of primary branches per plant and maximum fresh and dry weight of seed and stover could be associated with the availability of larger area per plant, implying that individual plants planted at wider row spacing received higher growth inputs (light, water, and nutrients) with less competition than those cultivated at closer spacing. The results are in close conformity with findings of Yadav *et al*. (2002) [14] in fennel, Krishnamurthy *et al*. (2000) [8], Nath *et al*. (2008) [12[]] and Naruka *et al*. (2012) [11] in ajwain.

Highest plant height (165.97 cm), higher number of primary branches $plant^{-1}$ (11.82), maximum fresh weight and dry weight of seed (47.79 g and 30.68 g) and stover (155.61 g and 51.28 g) at harvest were found in application of higher levels of fertilizer F_3 (100:50:40 N, P_2O_5, K_2O kg ha^{-1}) which was *on par* with fertilizer level F_2 (90:40:30 kg N, P_2O_5, K_2O kg ha^{-1}). The higher fertilizer levels resulted in increased plant height, number of leaves, branching and fresh weight, which aided in achieving maximum dry weight. It is generally known that nitrogen supports the vegetative growth which increases with higher nitrogen levels causing luxuriant plant growth, which is evident from higher fresh weight of seed and stover. The findings of this investigation are in close conformity with those of Krishnamoorthy and Madalgiri (2002) [7], Wahab and Mohamed (2007) [13], Nath *et al*. (2008) [12], Naruka *et al*. (2012) [11] in ajwain.

Effect of geometry and fertilizer levels on yield parameters of fennel

The data on number of umbels per plant, number of umbellet per umbel, number of seeds per umbellet, seed yield were given in Table 2. The maximum number of umbels per plant, number of umbellet per umbel and number of seeds per umbellet (29.22, 36.72 and 32.32 respectively) were obtained at 60 x 40 cm spacing and it was statistically similar to 60 x 30 cm (S_2) (28.46, 35.96 and 31.56). Crops grown under spacing 60 x 30 cm (S_2) produced higher seed yield (1234.12

g per plot) and (1714.06 kg ha^{-1}). The minimum number of umbels per plant, number of umbellet per umbel, number of seeds per umbellet (21.92, 29.42 and 32.32) and seed yield (1170.20 g plot^{-1} and 1624.63 kg ha^{-1}) were observed under 60 x 20 cm spacing. Under wider spacing reduced population per unit area though, improved overall growth of crop and increased crop yield components but failed to record highest yield due to less number of plants per hectare. These findings in close conformity of Yadav and Khurana (2000) [15], Yadav *et al*. (2002) [14] in fennel, Nandal *et al*. (2010) [10], Jan *et al*. (2011) in coriander, Krishnamurthy *et al*. (2000) [8], Nath *et al*. (2008) [12] and Naruka *et al*. (2012) [11] in ajwain.

Application of F_3 (100:50:40 N, P_2O_5, K_2O kg ha^{-1}) recorded maximum number of umbels per plant, number of umbellets per umbel and number of seeds per umbellet (28.28, 35.78 and 31.38 respectively) and it was *on par* with F_2 (90:40:30 N, P_2O_5, K_2O kg ha^{-1}) (27.00, 34.50 and 30.10 respectively). Minimum number of umbels per plant, number of umbellets per umbel and number of seeds per umbellet (20.97, 31.82 and 27.42 respectively) were found in F_1 (80:30:20 N, P_2O_5, K_2O kg ha^{-1}). The maximum seed yield (1220.60 g plot^{-1}) and (1695.29 kg ha^{-1}) was recorded in 100:50:40 N, P_2O_5, K_2O kg ha^{-1} (F_3) level of fertilizer and it was statistically *on par* with (90:40:30 kg N, P_2O_5, K_2O kg ha^{-1}) (F_2) (1212.46 g plot^{-1}) and (1683.99 kg ha^{-1}). The minimum seed yield (1190.86 g plot^{-1}) and (1653.32 kg ha^{-1}) was recorded under F_1 (80:30:20 N, P_2O_5, K_2O kg ha^{-1}). This might be due to supply of nutrients for plant and better uptake of elements in levels of nitrogen fertilizer, plants were better able to absorb nutrients as needed to grow and increase the yield parameters. Application of phosphorus might have resulted in increased carbohydrate accumulation and their remobilization to reproductive parts of the plants. Potassium is necessary in young growing tissues for cell elongation and cell division. The results are in the conformity with that of Nath *et al*. (2008) [12] in Ajwain, Mehta *et al*. (2011) [9] in fennel, Naruka *et al*. (2012) [11] in Ajwain and Yadav *et al*. (2017) [16] in fennel.

Table 1: Effect of geometry and fertilizer levels on growth parameters of fennel at harvest

Treatments	Plant height (cm)	Number of primary branches per plant	Fresh weight		Dry weight	
			Seed (g)	Stover (g)	Seed (g)	Stover (g)
Spacing (S)						
S_1: 60 x 20 cm	169.97	11.15	33.58	102.85	19.50	33.51
S_2: 60 x 30 cm	164.08	11.72	46.27	154.17	30.85	51.31
S_3: 60 x 40 cm	156.41	11.97	59.52	201.13	40.65	68.14
S.Em ±	1.01	0.07	0.51	0.95	0.05	0.10
C.D @ 5%	3.96	0.28	1.99	3.72	0.21	0.38
Fertilizer levels (F)						
F_1: 80:30:20 N, P_2O_5, K_2O kg ha^{-1}	160.41	11.40	44.47	149.42	29.87	50.66
F_2: 90:40:30 N, P_2O_5, K_2O kg ha^{-1}	164.08	11.61	47.11	153.12	30.45	51.03
F_3: 100:50:40 N, P_2O_5, K_2O kg ha^{-1}	165.97	11.82	47.79	155.61	30.68	51.28
S.Em ±	1.11	0.11	0.34	0.91	0.08	0.08
C.D @ 5%	3.44	0.33	1.03	2.79	0.24	0.26
Interaction (S x F)						
S_1F_1	167.30	11.07	31.15	99.94	19.43	33.32
S_1F_2	170.30	11.17	34.25	102.65	19.50	33.45
S_1F_3	172.30	11.20	35.33	105.97	19.55	33.77
S_2F_1	161.30	11.50	45.07	151.81	30.05	50.94
S_2F_2	164.63	11.77	46.70	154.40	31.14	51.47
S_2F_3	166.30	11.90	47.03	156.29	31.36	51.55
S_3F_1	152.63	11.63	57.18	196.51	40.12	67.73
S_3F_2	157.30	11.90	60.38	202.30	40.70	68.17
S_3F_3	159.30	12.37	61.01	204.57	41.12	68.53
S.Em ±	1.93	0.18	0.58	1.57	0.14	0.15
C.D @ 5%	NS	NS	NS	NS	0.42	NS

Table 2: Effect of geometry and fertilizer levels on yield parameters of fennel at harvest

Treatments	Number of umbels per plant	Number of umbellet per umbel	Number of seeds per umbellet	Seed yield (g plot^{-1})	Seed yield (kg ha^{-1})
Spacing (S)					
S_1: 60 x 20 cm	21.92	29.42	25.02	1170.21	1624.63
S_2: 60 x 30 cm	28.46	35.96	31.56	1234.12	1714.06
S_3: 60 x 40 cm	29.22	36.72	32.32	1219.61	1693.91
S.Em ±	1.50	1.34	1.50	2.51	3.85
C.D @ 5%	5.89	5.25	5.89	9.84	15.10
Fertilizer levels (F)					
F_1: 80:30:20 N, P_2O_5, K_2O kg ha^{-1}	24.32	31.82	27.42	1190.87	1653.32
F_2: 90:40:30 N, P_2O_5, K_2O kg ha^{-1}	27.00	34.50	30.10	1212.47	1683.99
F_3: 100:50:40 N, P_2O_5, K_2O kg ha^{-1}	28.28	35.78	31.38	1220.60	1695.29
S.Em ±	0.31	0.26	0.31	2.70	3.72
C.D @ 5%	0.94	0.79	0.94	8.32	11.47
Interaction (S x F)					
S_1F_1	20.97	28.47	24.07	1166.40	1618.01

S_1F_2	21.70	29.20	24.80	1170.56	1625.79
S_1F_3	23.10	30.60	26.20	1173.66	1630.09
S_2F_1	25.30	32.80	28.40	1202.30	1669.86
S_2F_2	29.57	37.07	32.67	1245.68	1730.12
S_2F_3	30.50	38.00	33.60	1254.38	1742.21
S_3F_1	26.70	34.20	29.80	1203.91	1672.10
S_3F_2	29.73	37.23	32.83	1221.16	1696.06
S_3F_3	31.23	38.73	34.33	1233.76	1713.56
S.Em ±	0.53	0.44	0.53	4.68	6.45
C.D @ 5%	1.63	1.36	1.63	14.41	19.86

Conclusion

Fennel planted at 60 x 40 cm spacing and application of 100:50:40 N, P_2O_5, K_2O kg ha^{-1} (F_3) recorded maximum number of primary branches per plant, fresh and dry weight of seed and stover, umbels per plant, umbellets per umbel and seeds per umbellet and it was on par with 60 x 30 cm spacing with (F_2) (90:40:30 kg N, P_2O_5, K_2O kg ha^{-1}). Highest seed yield was obtained under 60 x 30 cm spacing with application of 100:50:40 N, P_2O_5, K_2O kg ha^{-1} (F_3) level of fertilizer and it was on par with (90:40:30 kg N, P_2O_5, K_2O kg ha^{-1}) (F_2).

References

1. Anonymous. Horticultural crop statistics of Karnataka state at a glance, 2018. www.horticulture.kar.nic.in
2. Anonymous, Spices Board Statistic Data, 2020. www.indianspices.com
3. Badgujar SB, Patel VV, Bandivdekar AH. Foeniculum *vulgare* Mill: A review of its botany, photochemistry, pharmacology, contemporary application and toxicology. Biomed Res. Int. 2014;842674:1-32.
4. Balasubramaniyan P, Palaniappan SP. Principle and Practices of Agronomy. Agrobios, Jodhpur, 2005, pp. 158-185.
5. Dubey SK, Lal JP. Yield behavior of S-308 meican wheat under different spacing and fertilizer practices. Indian J. Agron. 1971;16(2):182-184.
6. Jan IM, Sajid AH, Shah, Rab NH, Khan FI, Wahid A, Rahman R, Alam. Response of seed yield of coriander to phosphorus and row spacing. Sarhad J Agric. 2011;27(4):549-552.
7. Krishnamoorthy V, Madalagari MB. Effect of nitrogen and phosphorus on growth of ajowan genotypes (*Trachyspermum ammi* L.). J Med. Aromat. Plant Sci. 2002;24(1):45-49.
8. Krishnamoorthy V, Madalagari MB, Basavaraj N. Response of ajowan (*Trachyspermum ammi* L.) to seed rate and spacing. Int. J. Trop. Agric. 2000;18(2):379-383.
9. Mehta RS, Anwer MM, Aishwath OP. Growth and yield of fennel (*Foeniculum vulgare* Mill.) as influenced by irrigation, nutrient levels and crop geometry. J Spices Aromat. Crops. 2011;20(2):77-80.
10. Nandal JK, Dahiya MS, Vishal G, Bamel J, Telhan SK. Response of spacing, phosphorus level and cutting of leaves on growth and yield of coriander. Indian J Hortic. 2010;67:271-275.
11. Naruka IS, Singh PP, Megha B, Rathore SS. Effect of spacing and nitrogen levels on growth, yield and quality of ajwain (*Trachyspermum ammi* L.). International J. Seed Spices. 2012;2(1):12-17.
12. Nath P, Jaiswal RC, Verma RB, Yadav GC. Effect of date of sowing, nitrogen levels and spacing on growth and yield of ajwain (*Trachyspermum ammi* L.). J Spices Aromat. Crops. 2008;17(1):1-4.
13. Wahab AE, Mohamed A. Effect of Nitrogen and Magnesium Fertilization on the Production of Ajwain (*Trachyspermum ammi* L.) Plants under Sinai Conditions. J Appl. Sci. Res. 2007;3(8):781-786.
14. Yadav AC, Yadav JS, Dhankhar OP, Singh A. Yield and yield attributes of fennel (*Foeniculum vulare* Mill.) as influenced by various row spacing and plant spacings. Haryana Agric. Univ. J Res. 2002;29(3-4):233-235.
15. Yadav BD, Khurana SC. Effect of plant population and row spacing on quality of seed produced by different order umbels in transplanted fennel. Haryana J Hortic. Sci. 2000;29(3-4):233-235.
16. Yadav BL, Patel AM, Patel BS, Shaukat Ali, Jintendra S. Quality and soil fertility as influenced by different row spacing and intercropping systems in *rabi* fennel (*Foeniculum vulagare* Mill.). Adv. Res. J Crop Improvt. 2017;8(1):75-79.