Journal of Scientific Research and Reports

Volume 30, Issue 12, Page 557-566, 2024; Article no.JSRR.127803
ISSN: 2320-0227

Response of *Rabi* Fennel (*Foeniculum vulgare* Mill.) Varieties to Sowing Time and Row Spacing under Semi-arid Region of Banaskantha, Gujarat, India

Y. A. Tamboli [a++*] and A. U. Amin [b#]

[a] School of Agricultural Sciences, Jaipur National University, Jaipur, Rajasthan-302 017, India.
[b] Seed Spices Research Station, Jagudan, S. D. Agricultural University, Sardarkrushinagar, Gujarat-385 506, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jsrr/2024/v30i122700

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/127803

Original Research Article

Received: 08/10/2024
Accepted: 10/12/2024
Published: 20/12/2024

ABSTRACT

The yield of crops depends on climatic, soil and crop management factors, among them optimum time of sowing has becomes a prime importance for higher productivity. Crop varieties respond differently to sowing time as well as optimum row spacing is important for maximizing light interception, distribution and light penetration in crop canopy. So that in 2015-16, a field experiment was carried out to examine the consequences of different sowing time, varieties and row spacing on growth, yield and phenology of *rabi* fennel. The significantly tallest plant height and higher number

---

[++] Assistant Professor;
[#] Research Scientist (Retd.);
**Corresponding author: E-mail: yasirtamboli786@gmail.com;*

Cite as: *Tamboli, Y. A., and A. U. Amin. 2024. "Response of Rabi Fennel (Foeniculum Vulgare Mill.) Varieties to Sowing Time and Row Spacing under Semi-Arid Region of Banaskantha, Gujarat, India". Journal of Scientific Research and Reports 30 (12):557-66. https://doi.org/10.9734/jsrr/2024/v30i122700.*

of branches (primary, secondary and tertiary) per plant, number of seeds per umbellate, seed yield per plant, seed, stover and biological yield as well as more number days to 50 per cent flowering and days to physiological maturity recorded under early sowing *i.e.* 3rd week of October. Fennel variety GF-12 superior over GF-11 and GF-2 in terms of the growth and yield parameters. Whereas, row spacing of 45 cm recorded higher growth and yield parameters over 60 cm. However, spacing did not exhibit a significant influence on harvest index, days to 50 per cent flowering and days to physiological maturity. The Interaction effect of time of sowing and row spacing was found significant in primary branches, number of umbels and seed yield per plant as well as seed yield. It was found that growth and yield attributing characters significantly correlated with seed yield.

Keywords: Growth; phenology; yield sowing time; spacing; variety; fennel.

1. INTRODUCTION

Seed spices are aromatic herbs of tropical origin, whose dried seeds are used as spices in pulverized state, primarily for garnishing the foods and beverages and generally cultivated in the arid and semi-arid region in dry or wet cool weather conditions. The spices attaining importance day by day due to its medicinal and aromatic values. Presently, demand of Indian spices increased at international level. Globally, India is largest consumer, producer and exporter of spices, that's why India is known as 'home of spices'. In India, Rajasthan and Gujarat and parts of Madhya Pradesh known as 'seed spices bowl" contributing more than 80 per cent of the country's annual seed spice production.

Fennel (saunf) is important *rabi* spices crop, originated from southern Europe and Asia minor comes under 'Apiaceae' family commonly grown for its seed, leaves and edible shoots. The data showed that in 2022-23, India produces 137 thousand metric tones from 82142 hectare area and productivity of 1672 kg/ha (Anon, 2023[a]). It produced 98272 metric tones of fennel from 47549 ha area and productivity of 2066 kg/ha (Anon, 2023[b]). "Fennel is important commercial crops and it is the top-ranked export of herbs and spices from India. As per the estimate about 35 thousand tons of fennel worth of Rs 309 crore exported during 2022-23" (Anon, 2023[c]).

The selection of an appropriate sowing time is crucial for optimizing plant growth and achieving maximum yield by utilizing natural resources efficiently during the growing seasons. Adjustment of sowing time as per the crop requirement creates favorable conditions in terms of ecological and environmental, which provides opportunity time to increase the fennel yield per unit area. For higher crop production, selection of variety is an important adaptation strategy and one of many decisive actions that must be taken up to reliably produce stable yields in changing environment and type of soil. So that, selecting a superior fennel variety according to the soil and climatic conditions plays an important part in enhancing the productivity. The morphology of fennel requires optimum space to reduce the competition for moisture, space, sunlight and nutrient. Availability of more sunlight and minimize the competition within the crop plants results in higher yield per plant under wider row spacing, but decrease in number of plants per unit area and ultimately yield. Whereas, closer row spacing than optimum effect on yield and quality due competition within the crop plants for moisture, nutrient, light and air. So that, optimum crop geometry as per the plant geometry exhibits higher yield of fennel. "In addition proper spacing is important for maximizing light penetration, interception, light distribution in crop canopy and average light utilization efficiency affects the yield of a crop" (Mehmood et al., 2012). A study found that fennel sown at optimum space of 45 cm recorded significantly higher growth, yield, quality and economics as compared to over 60 cm (Tamboli and Amin, 2024) and Amin et al. (2005) also reported that 45 cm row spacing in fennel recorded significantly higher plant height, number of branches, umbels per plant, umbellates per umbel, seeds per umbel, seed yield and oil content as compared to over 30 cm and 60 cm row spacings. This article summarizes the most favorable time for planting cultivars, and optimum spacing under North Gujarat agro-climatic condition. This information may be useful for fennel growers and researchers.

2. MATERIALS AND METHODS

Site specifications and weather: A field experiment was conducted during 2015-16 in rabi season at Agronomy Instructional Farm of Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural

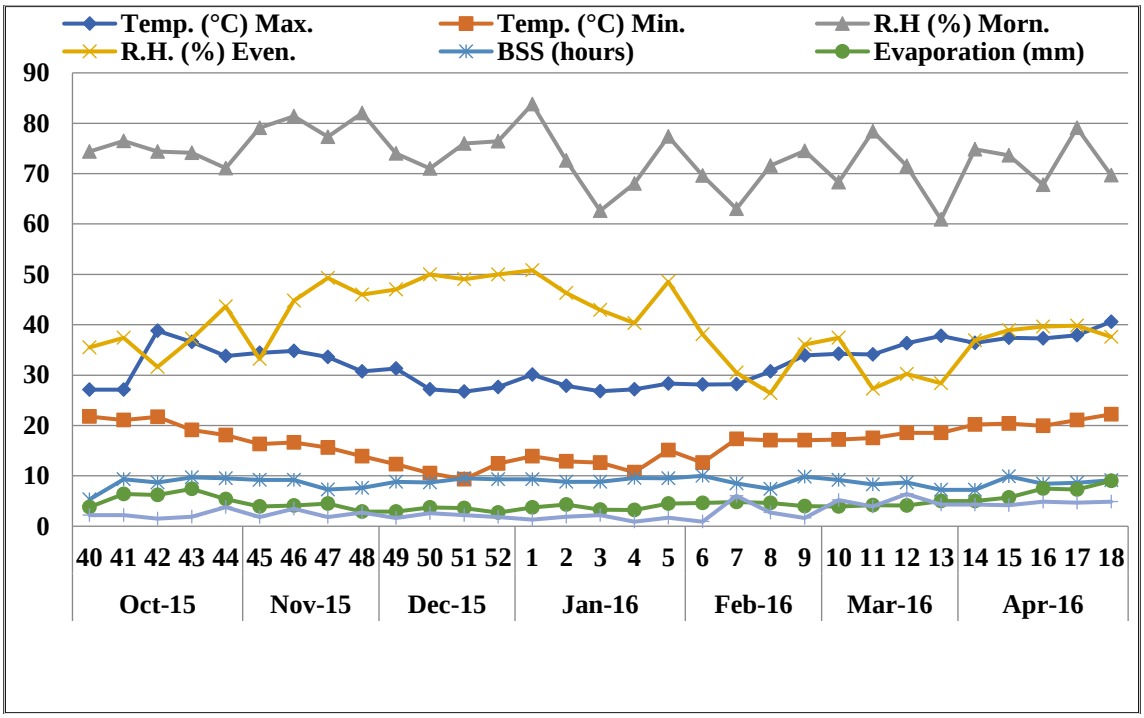

Fig. 1. Mean weekly weather data recorded during crop growth period of 2015-16

University, Sardarkrushinagar, Gujarat. The site is located in sub-tropical monsoon region of North-east zone of Gujarat which comes under 24˚/19' North latitude and 72˚/19' East longitude with an elevation of 154.52 meters above mean sea level. A weather condition in winter is fairly cold and dry while summer is quite hot and dry. Average temperature in winter season is 12.2°C and annual average rainfall is 620.9 mm (Fig. 1).

Sampling and analyses: The pH of the experimental soil was 7.4 (neutral) having EC of 0.10 ds/m (Rechard, 1954). The soil content 0.17 per cent, 159 kg/ha, 39 kg/ha and 271 kg/ha of organic carbon (Walkely and Black, 1947), available nitrogen (Subbaiah and Asija, 1956), available phosphorus (Olsen et al. 1954) and available potassium (Jackson, 1973), respectively.

Experimental setup: The experiment was laid out *rabi* season in spilt plot design with three sowing times (D_1:3rd week of October, D_2:1st week of November and D_3: 3rd week of November) as main plot, three varieties (V_1: Gujarat Fennel-2, V_2: Gujarat Fennel-11 and V_3: Gujarat Fennel-12) and two spacings (S_1: 45 cm and S_2: 60 cm) in sub plot having eighteen treatment combinations with four replications. The fennel was fertilized with RDF (90: 30: 30 NPK Kg/ha). The seed rate of 4.5 kg per were taken for sowing. Irrespective of treatments, thinning of extra plant was done 20 DAS by hand pulling to maintain the intra-row spacing of 15 cm. The need based agronomic practices was carried out for the better crop growth and development.

Observation recorded: For recording various growth and yield attributes, five plants were selected from each plot. The net plot yield was converted in kg per hectare. Harvest index was calculated by using the formula given by Donald and Hamblin (1962). The statistical analysis was carried out as per design of the experiment and simple correlation coefficient ('r') of each character was calculated.

3. RESULTS AND DISCUSSION

Influence of sowing time: The data in Table 1 showed that significantly tallest plant height of 11.5, 47.0, 127.6 and 145.2 cm at 30, 60, 90 and 120 DAS, respectively and number of primary (6.8), secondary (6.4) and tertiary (5.0) branches per plant recorded under 3rd week of October. The per cent increase in number of primary, secondary and tertiary branches per plant due to early sowing (3rd week of October) were 7.9, 8.9 and 6.3 per cent, respectively higher than 1st week of November and 18.8, 31.7 and 18.3 per cent respectively higher than 3rd week of

November (Fig. 2). It might be due to favourable ecological conditions and availability of optimum moisture, nutrient, air and sunshine hours for vegetative growth which helped to increase number of branches (Fig. 3). Whereas, unfavourable climatic condition under late sown crop might had reduced growth and number of branches. Similar findings have been reported by Patel (2000), Yadav and Khurana (2000), Ayub et al. (2008), Bagari et al. (2010), Selim et al. (2013) and Tamboli and Amin (2024).

The significantly higher number of seeds (20.5) per umbellate, seed yield per plant (26.1 g), seed (1.4 t/ha), stover (4.1 t/ha) and biological yield (5.5 t/ha) as well as a greater number of days of 110.9 to 50 per cent flowering and 173.8 days to physiological maturity recorded under early sown fennel *i.e.* 3rd week of October (Table 2 & Fig. 4). Under early sown crop, the favourable climatic condition throughout the crop season and availability of more sunshine hours, moisture, nutrients and air for vegetative growth might have production of more photosynthates as well as its translocation to the sites enhanced growth which showed significantly positive correlation with yield. Whereas, delay sowing increase in temperature at latter stage and suppressed the initial vegetative growth and ultimately poor reproductive growth and forced for early maturity consequently reduced seed yield. These results are with line of work reported by Singh et al*.* (2005), Singh et al*.* (2009), Meena et al*.* (2015) and Tamboli and Amin (2024).

Influence of variety: The significantly tallest plant height was recorded under variety GF-12 (V_3) at 30 (11.1 cm), 60 (46.1 cm), 90 (128.8 cm) and 120 (143.4 cm) DAS as well as number of primary (6.8), secondary (6.4) and tertiary (5.0) branches per plant over GF-2 and was at par with GF-11 (Table 1). But varieties could not exhibit any influence on plant population. The inherent characteristic of variety plays a key role in growth and development of fennel (Figs. 2 & 3). These results are with line of work concluded by Singh et al*.* (2003), Malik et al*.* (2009) and Sengupta et al*.* (2014).

The significantly higher number of seeds per umbellate (20.8), seed yield per plant (26.1 g), harvest index (25.9), seed (1.4 t/ha), stover (4.0 t/ha) and biological yield (5.4 t/ha) as well as more number days to 50 per cent flowering (111.1) and days to physiological maturity (172.0) were observed under GF-12 over GF-2 (Table 2 & Fig. 4). The higher seed and stover yield recorded with GF-12 was 10.9 and 23.9 as well as 4.4 and 13.4 per cent higher over GF-11 and GF-2, respectively. Taller plants with a greater number of branches were recorded under GF-12 and GF-11 is contributed to genetic setup of particular variety, which could have increased stover yield. These findings are in close agreement with those of Malik et al*.* (2009), Meena and Singh (2013) and Tamboli and Amin (2024).

Influence of row spacing: The significantly higher plant population at initial (324.7) and harvest (312.2), plant height at 60 (45.8 cm), 90 (126.5 cm) and 120 (141.3 cm) DAS and number of primary (6.5), secondary (5.9), tertiary (4.8) branches per plant were recorded with 45 cm row spacing as compared to wider row spacing *i.e.* 60 cm (Table 1). These findings are corroborated with the results of Amin et al*.* (2005) and Mehta et al*.* (2011).

The data showed in Table 2 revealed that the significantly higher number of seeds per umbellate (19.9), seed yield per plant (24.9 g), seed (1.4 t/ha), stover (3.9 t/ha) and biological yield (5.2 t/ha) were recorded with 45 cm row spacing. The inter row spacings did not influence any positive or negative effect on harvest index and days to 50 per cent flowering and physiological maturity. The increase in seed, stover and biological yield due to sowing of crop at 45 cm apart was 11.9 and 5.4 per cent, respectively than wider row spacing of 60 cm. Optimum space available for individual plants might have resulted in better utilization of resources to improve vegetative growth and consequently reproductive growth. These findings are in conformity with results reported by Singh (2001), Amin et al*.* (2005), Bhuva et al. (2017), Tamboli and Amin (2024).

Interaction between of sowing time and variety: Interaction effect between time of sowing and variety was found significant for number of primary branches per plant, number of umbels, seed yield per plant and seed yield. (Table 3). Significantly the highest primary branches per plant (6.9), number of umbels per plant (20.6), seed yield per plant (28.3 g) as well as seed yield (1.5 t/ha) were recorded when crop sown in 3rd week of October keeping 45 cm row spacing (D_1S_1). Whereas number of primary branches per plant and umbels per plant it was found statistically at par with treatment combinations of D_2S_1 and D_1S_2 (Tamboli et al., 2020; Mohan et al., 2001).

Correlation coefficient: It was noticed that significantly positive correlation of seed yield with growth and yield attributing parameters viz. number of primary, secondary and tertiary branches per plant, number of seeds per umbellate and seed yield per plant (Table 4).

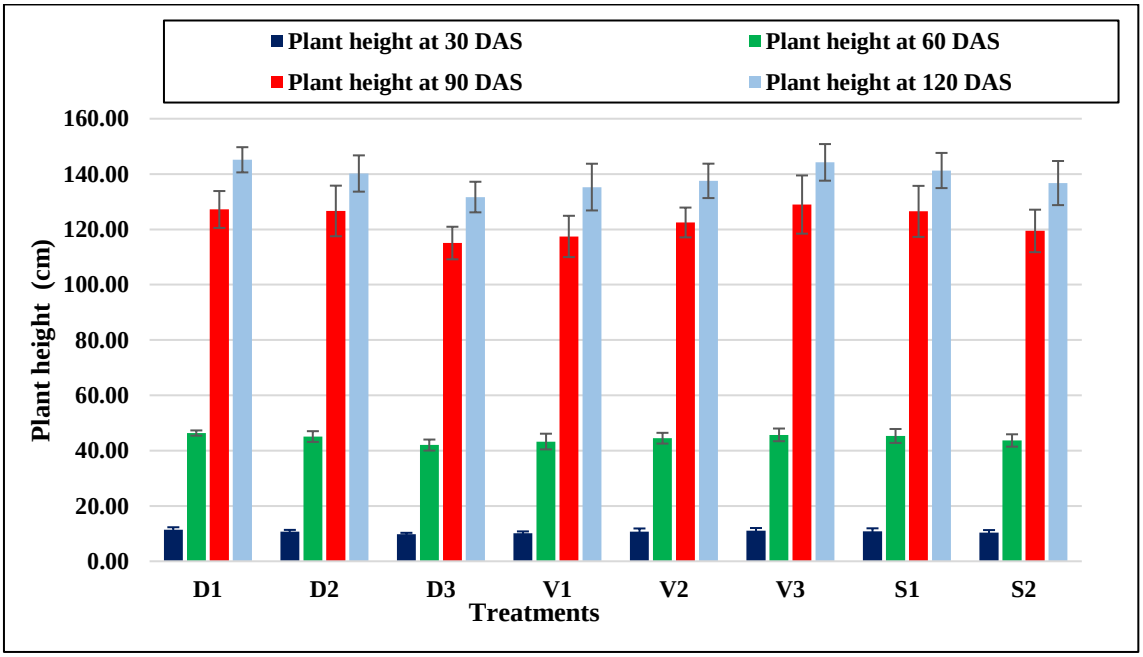

Fig. 2. Influence of sowing time, variety and row spacing on plant height at 30, 60, 90 and 120 DAS

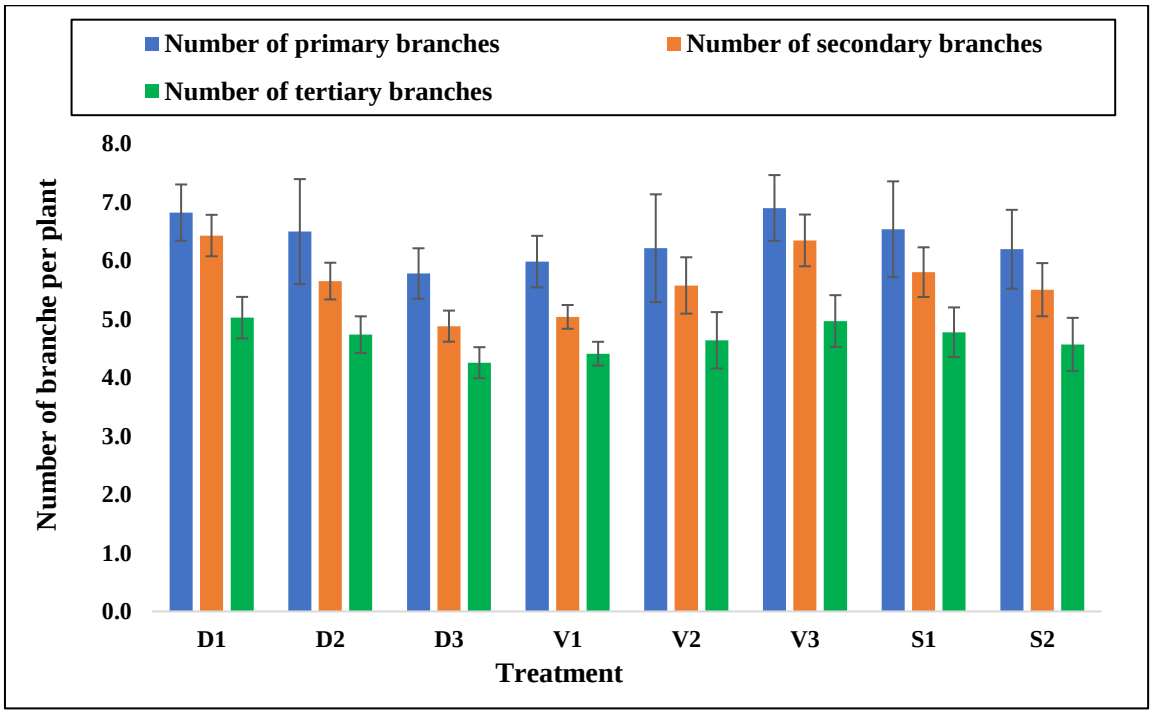

Fig. 3. Influence of sowing time, variety and row spacing on number of primary, secondary and tertiary branches per plant

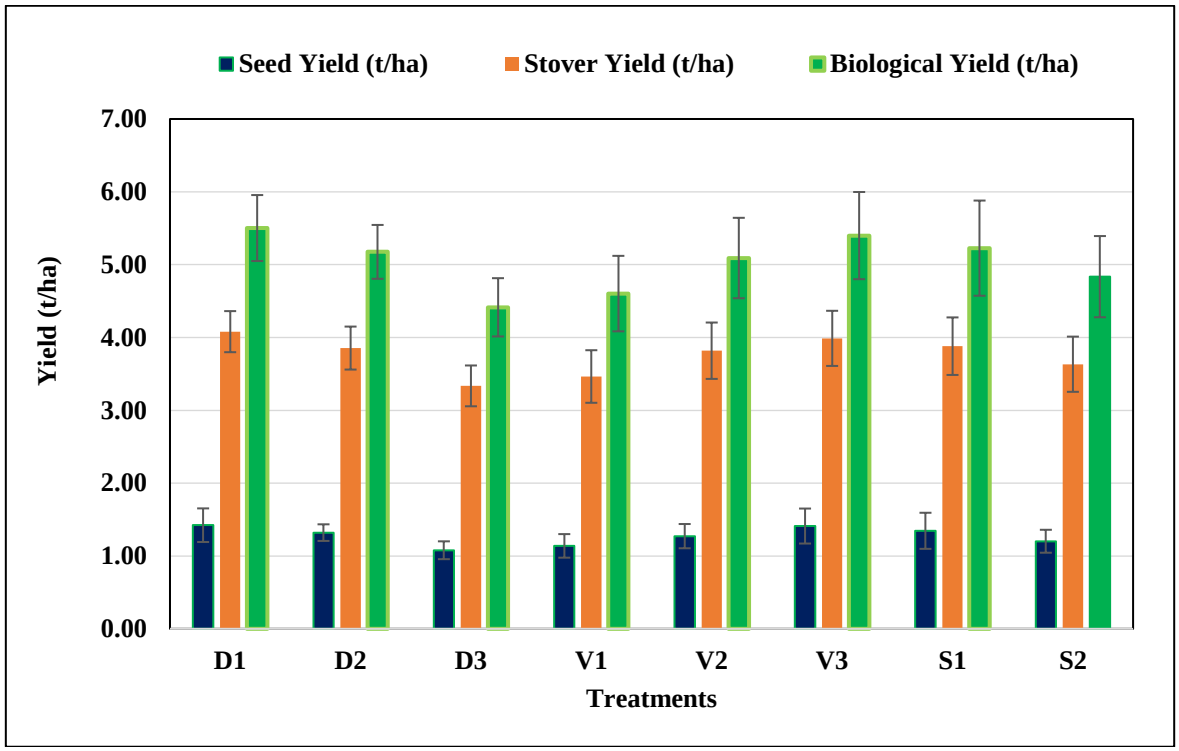

Fig. 4. Effect of of time of sowing, variety and row spacing on seed, stover and biological yield (t/ha)

Table 1. Influence of time of sowing, variety and row spacing on growth attributes of *rabi* fennel

Treatments	Plant population		Plant height (cm)				Number of branches per plant at harvest		
	Initial	Harvest	30 DAS	60 DAS	90 DAS	120 DAS	Primary	Secondary	Tertiary
Times of sowing (D)									
D_1:3rd week of October	284.2	274.8	11.5	47.0	127.6	145.2	6.8	6.4	5.0
D_2 :1st week of November	274.9	266.7	10.7	45.1	126.7	140.2	6.3	5.9	4.7
D_3 :3rd week of November	275.5	265.9	9.7	42.0	115.1	131.7	5.7	4.9	4.3
S.Em.±	7.2	7.1	0.3	1.1	3.0	3.0	0.2	0.2	0.1
C.D. at 5%	NS	NS	1.0	3.7	10.4	10.3	0.5	0.6	0.3
Varieties (V)									
V_1 : GF 2	276.6	263.9	10.2	43.3	117.4	135.3	6.0	5.3	4.4
V_2 : GF 11	277.9	270.8	10.7	44.7	123.0	138.4	6.1	5.6	4.6
V_3 : GF 12	280.1	272.7	11.1	46.1	128.8	143.4	6.8	6.4	5.0
S.Em.±	4.9	6.0	0.2	0.7	2.1	1.9	0.1	0.1	0.1
C.D. at 5%	NS	NS	0.6	2.0	5.9	5.4	0.4	0.3	0.2
Spacings (S)									
S_1 : 45 cm	324.7	312.2	10.9	45.8	126.5	141.3	6.5	5.9	4.8
S_2 : 60 cm	231.7	226.1	10.4	43.7	119.7	136.7	6.1	5.6	4.6
S.Em.±	4.0	4.9	0.2	0.6	1.7	1.5	0.1	0.1	0.1
C.D. at 5%	11.5	13.9	NS	1.7	4.8	4.4	0.3	0.3	0.2

Table 2. Influence of time of sowing, variety and row spacing on growth attributes of *rabi* fennel

Treatments	Days to 50 per cent flowering	Days to physiological maturity	Number of seeds per umbellate	Seed yield per plant (g)	Harvest index (%)	Seed Yield (t/ha)	Stover Yield (t/ha)	Biological Yield (t/ha)
Times of sowing (D)								
D_1	110.9	173.8	20.5	26.1	25.8	1.4	4.1	5.5
D_2	109.4	169.0	19.7	24.1	24.9	1.3	3.9	5.2
D_3	102.5	166.0	18.1	22.3	24.3	1.1	3.3	4.4
S.Em.±	2.0	1.7	0.4	0.7	0.5	0.03	0.1	0.1
C.D. at 5%	6.9	5.8	1.5	2.3	NS	0.1	0.4	0.4
Varieties (V)								
V_1	104.7	167.0	18.3	22.3	24.2	1.1	3.5	4.6
V_2	107.0	169.8	19.3	24.0	24.8	1.3	3.8	5.1
V_3	111.1	172.0	20.8	26.1	25.9	1.4	4.0	5.4
S.Em.±	1.6	1.4	0.3	0.5	0.5	0.02	0.1	0.1
C.D. at 5%	4.4	3.8	0.9	1.5	1.3	0.1	0.2	0.2
Spacings (S)								
S_1	107.9	169.9	19.9	24.9	25.5	1.4	3.9	5.2
S_2	107.3	169.3	19.0	23.4	24.5	1.2	3.6	4.8
S.Em.±	1.3	1.1	0.3	0.4	0.4	0.02	0.1	0.1
C.D. at 5%	NS	NS	0.8	1.3	NS	0.1	0.15	0.2

Note: See Table 1 for treatment details

Table 3. Interaction effect of time of sowing and row spacing

Treatments	Primary branches/plant		Number of umbels/plants		Seed yield/plant (g)		Seed yield (t/ha)	
Spacings (S)	**S_1**	**S_2**	**S_1**	**S_2**	**S_1**	**S_2**	**S_1**	**S_2**
Times of sowing (D)								
D_1	6.9	6.8	20.6	20.2	28.3	23.9	1.5	1.3
D_2	6.8	5.9	20.3	17.3	23.8	24.4	1.4	1.3
D_3	5.7	5.8	18.0	17.1	22.7	21.8	1.1	1.0
S.Em.±	0.2		0.6		0.9		0.1	
C.D. at 5%	0.6		1.8		2.7		1.3	

Note: See Table 1 for treatment details

Table 4. Correlation coefficient between seed yield and growth as well as yield parameters

S. No.	Parameters	'r' value
1.	Primary branches per plant	0.80**
2.	Secondary branches per plant	0.90**
3.	Tertiary branches per plant	0.88**
4.	Seeds per umbellate	0.83**
5.	Seed yield per plant	0.88**

** Significant at 5% level*
*** Significant at 1% level*

4. CONCLUSION

The finding of this study indicated that as per adaptability to local climatic conditions selection of suitable fennel variety GF-12 at optimum sowing time *i.e.* 3rd week of October and optimum row spacing as per the plant geometry *i.e.* 45 cm for higher growth and yield under North Gujarat Agro-climatic condition.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

ACKNOWLEDGEMENT

The authors are highly obliged to Department of Agronomy, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushingar, Gujarat for valuable guidance and help during research programme.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Amin, A.U., Singh, A., Patel, B. S. & Patel, J. K. (2005). Effect of various row spacing and nitrogen levels on drilled *Rabi* fennel (*Foeniculum vulgare* Mill.). *Agricultural Science Digest*, 25(1), 44-46.

Anonymous (2023 [b]). District-wise Area, Production and yield in Gujarat State during 2022-23. Directorate of Agriculture Gujarat State Gandhinagar, p. 32.

Anonymous (2023 [c]). Item-wise export of spices from India during 2022-23. Directorate General of Commercial Intelligence and Statistics, Ministry of Commerce and Industry, Government of India, p. 42.

Anonymous (2023[a]). State of Indian Agriculture 2022-23. Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India, New Delhi, p. 202-205.

Ayub, M., Nadeem, M. A., Tanveer, A., Tahir, M., Saqib, M.T.Y. & Nawaz, R. (2008). Effect of different sowing methods and times on the growth and yield of fennel (*Foeniculum vulgare* Mill.). *Pakistan Journal of Botany*, 40(1), 259-264.

Bagari, S., Singh, P. P., Naruka, I. S., Rathore, S. S. & Shaktawat, R. P. S. (2010). Effect of date of sowing and nitrogen levels on growth, yield and quality of fennel (*Foeniculum vulgare* Mill.). *Indian Journal of Horticulture,* 67(4), 518-524.

Bhuva, H. M. Detroja, A. C. & Patoliya, B. V. (2017). Growth and yield of drilled *rabi* fennel (*Foeniculum vulgare* mill.) as influenced by various row and plant spacing. *The Bioscan*, 12(2), 1111-1113.

Donald, C.N. and Hamblin, J. (1962). The biological yield and harvest index of

cereals as agronomic and plant breeding criteria. *Advance Agronomy,* 28, 361-405.

Jackson, M. L. (1973). Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

Malik, T. P., Tahlan, S. K. & Thakral, K. K. (2009). Performance of fennel (*Foeniculum vulgare Mill.*) genotype for seed yield. *Annals of Horticulture*, **2**(2), 243-245.

Meena, M. L. and Singh, D. (2013). On-farm assessment of fennel varieties in Rajasthan. *Journal of Spices and Aromatic crops,* 22(2), 200-202.

Meena, S. S., Mehta, R. S., Lal, G., Sharma, Y. K., Meena, R. D. & Kani, K. (2015). Effect of sowing dates and crop geometry on growth and seed yield of dill (*Anethum sowa* L.). *International Journal of Seed Spices,* 5(1), 79-82.

Mehmood, Z., Hussain, M., Khan, M.B., Farooq, S., Lee, D.J. & Farooq, M. (2012). Narrow row spacing ensures higher productivity of low tillering wheat cultivars. *International Journal of Agriculture Biology*, 14, 413-418.

Mehta, R. S., Anwer, M. M. & Aishwath, O. P. (2011). Growth and yield of fennel (*Foeniculum vulgare Mill*.) as influenced by irrigation, nutrient levels and crop geometry. *Journal of spices and Aromatic crops,* 20(2), 77-80.

Mohan, V. P., Batra, V. K. & Thakral, K. K. (2001). Response of sowing date and seed rates on growth and yield of fennel (*Foeniculum vulgare Mill*.). *Haryana Journal of Horticultural Science,* 30(3&4), 271-273.

Olsen, S. R., Cole, V. C., Watanable, P. S. & Dean, L. A. (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate. U.S.D.A., Circ. No. 939.

Patel, J. A. (2000). Effect of different sowing dates and spacings on the yield and quality of fennel (*Foeniculum vulgare* Mill.). M.Sc. (Agri). Thesis (Unpublished) submitted to Gujarat Agricultural University, Sardarkrushinagar.

Richards, L. A. (1954). Diagnosis and improvement of saline and alkaline soils. USDA hand Book No. 60, United States.

Selim, S. M., Ebtsam, M. M. A. Tawfic, M. S. H. & Abou-Sreea, A. I. (2013). Effect of sowing date, row spacing and bio-fertilizer on yield and oil quality of fennel (*Foeniculum vulgare* Mill.). *Australian Journal of Basic and Applied Science,* 7(2), 882-894.

Sengupta, S. K., Verma, B. K. & Naidu, A. K. (2014). Genetic variability study in fennel (*Foeniculum vulgare* Mill.). *International Science Journal*, 1(1), 62-64.

Singh, A. (2001). Response of drilled *rabi* fennel (*Foeniculum vulgare* Mill.) to spacings under varying levels of nitrogen. M.Sc. (Agri). Thesis (Unpublished) submitted to Gujarat Agricultural University, Sardarkrushinagar.

Singh, S. K., Tripathi, S. M. & Dwivedi, A. K. (2009). Effect of planting dates, sowing method and row spacing on yield of fennel (*Foeniculum vulgare* Mill.). *Annals of Horticulture,* 2(2), 249-250.

Singh, S., Buttar, G. S. & Singh, S. P. (2005). Fennel (*Foeniculum vulgare* Mill.) response to sowing dates and row spacings. *Haryana Journal of Agronomy,* 21(2), 202-203.

Singh, S., Butter, G. S. & Singh S. P. (2006). Growth, yield and heat unit requirement of fennel (*Foeniculum vulgare* Mill.) as influenced by date of sowing and row spacing under semi-arid region of Punjab. *Journal of Medicinal and Aromatic Plant Science,* 28(3), 363-365.

Singh, Y., Mittal, P. and Katoch, V. (2003). Evaluation of fennel genotypes under mid-hill humid sub-temperate conditions. *Himachal Journal of Agricultural Research,* 29(1&2), 48-51.

Subbiah, B. V. and Asija, G. C. (1956). A rapid procedure for the estimation of available nitrogen. *Current Science*, 25, 259-260.

Tamboli, Y. A., Amin, A. U., Patil J. K. & Jinendra Birla. (2020). Growth, Yield Attributes and Yield of rabi Fennel (*Foeniculum vulgare* Mill.) as Influenced by Different Time of Sowing, Variety and Spacing. *Int. J. Curr. Microbiol. App. Sci*. 9(04), 339-351. doi: https://doi.org/10.20546/ijcmas.2020.904.040

Tamboli, Y. A., and A. U. Amin. (2024). Impact of Time of Sowing, Variety and Crop Geometry on Growth, Yield, Quality and Economics of Rabi Fennel (*Foeniculum Vulgare* Mill.)". *International Journal of Plant & Soil Science*, 36(11), 50-58.

Walkely, A. and Black, I. A. (1947). Rapid titration method for organic carbon of soil. *Soil Science*, 37, 29-33.

Yadav, B. D. & Khurana, S. C. (2000). Effect of row spacing and plant population on growth and yield of fennel (*Foeniculum*

vulgare Mill.). *Haryana Agricultural University Journal of Research*, 30, 29-34.

Yadav, B.D., Khurana, S.C., Thakral, K.K. & Malik, Y.S. (2000). Effect of sowing date and planting method on quality of seed produced by different order umbel in fennel (*Foeniculum vulgare* Mill.). *Haryana Journal Horticultural Science,* 29(112), 108-110.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/127803