Impactof Time of Sowing, Variety and Crop GeometryonGrowth, Yield, Quality and Economicsof *Rabi* Fennel (*Foeniculum Vulgare*Mill.)

ABSTRACT

The fieldexperimentwas carried in *rabi* season of 2015-16 at Agronomy InstructionalFarm, S. D. Agricultural University, Sardarkrushinagar, Gujarat to examine the consequences of different time of sowing, varieties and spacing on *rabi* fennel.The experiment was laid out in spilt plot design with threesowing times(D_1:3rdweek of October, D_2:1stweek of Novemberand D_3:3rdweek of November)as main plot, threevarieties (V_1: GF-2, V_2: GF-11 and V_3: GF-12) and twospacings (S_1:45 cm and S_2:60 cm) insub plot with fourreplications. The results revealed that earlysown crop *i.e.*3rdweek of October recorded significantlyhigher growth and yield*viz,* plant height and total number of branches and umbels per plant,number of umbellates per umbel, test weight and seed yield as well as productivity per day, quality attributes*viz.*,volatile oil and protein content, volatile oil yield as well as economicsin term of gross andnet realization, net income per day and benefit cost ratio (BCR). While, fennel variety GF-12 superior in terms of growth, yield, quality as well as economics parameters over a GF-2 and GF-11. Whereas, fennel sown at optimum space of 45 cm recorded significantly highergrowth, yieldand economics as compared to over 60 cm,however spacing did not exhibit a significant influence on test weight, volatile oil and protein content. The interactive effect between 3rd week of October and 45 cmwas significantly superior as compared to rest of treatment combination.

Keywords: Growth, yield**,** qualityeconomics, fennel, time of sowing, variety, spacing.

INTRODUCTION

"Fennel is native tosouthern Europe and Asia minor and a perennial herb of carrot family 'Apiaceae'commonly grown for its seed, leaves and edible shoots and commonly known as saunf. India is known as home of spices because world's largest producer, exporter andconsumer of seed spices from India.However, Gujarat and Rajasthan contribute more than eighty percent of seed spices production of the country that's way both the states commonly known as India's "Seed Spices Bowl".In 2022-23, India produces 137 thousand metric tonesfrom 82142 hectare area with average productivity of 1672 kg/ha."(Anon, 2023[a]). "Whereas, more than ninety per cent of the fennel production comes from single state *i.e.*Gujarat.It produced 98272metric tones of fennel from 47549 ha area with average productivity of 2066 kg/ha" (Anon, 2023[b]). "The average highest productivity of fennel recorded in Gujarat,which is ranks first not only in India, but at international level also.It is considered one of the most important commercial crops for export, and it isthe top-ranked export of herbs and spices from India, exported about 35 thousand tons of fennel worth of Rs 309 crore during theyear 2022-23".(Anon, 2023[c]).

"Fennelis highly sought after throughout the worldfor use in cooking, various food preparation, candies, pickles, soups, sauces, liquors, bakery items *etc.* due to have a fragrant odour and a pleasant aromatic taste, long preservation timeas well as widely used as a medicine and cleaning due to its high content of vitamin C, fiber, andpotassiumwhereas, the leaves as well as seeds are digestive used for constipation, flatulence, colic, thirst, cough, diarrhea and dysentery" (Randhawa *et al.* 1978).

The impact of climate change on agriculture poses a significantthreat globally, as it exacerbates both biotic and abiotic stresses that affect fennel production. Therefore, it is crucial to consider the effects of climate change and sowing time on crop production and modeling to improve growth, yield and quality of the crop. Identifying the optimal sowing timefor new varieties in each region is the most significant and controllable factor for

maximizing cropyields (Zhang *et al.* 2023). The selection of an appropriate sowing time iscrucial for optimizing plant growth stages and achieving maximum yield by utilizing naturalresources efficiently during the growing seasons (Safaei *et al*., 2017). Fennel thrives on a dry and cold weather,long sunny days as well as15-30°C is the optimum temperature favours higher seed production. Whereas,temperature above 25°C for extended period usually retards development of fennel and in early growth may result premature flowering and very low seed yield.By adjustment sowing time as per the crop requirementcreates favorableconditions in terms of ecological and environmental for better performance of all morphological characters and physiological activities in plant and byavoiding from pest and diseases, which provides opportunity time to increase the fennel yield per unit area.

In general, selectionof variety is an important adaptation strategy in crop production and one of many decisive actions that must be taken up to reliably produce stable yields in changing climate. So that, selectinga superior fennel variety according to the soil and climatic conditions plays an important role in enhancing the growth, yield and quality. The optimum spacein any crop decided by its plant geometry.As per the morphology of fennel plant it requires optimum space to reduce the competition for moisture, space, sunlight and nutrient.A wider spacing allow higher photosynthetic area by availability of more sunlight and minimize the competition within the crop plants results in higher yield per plant, but decrease in number of plants per unit area and ultimately yield.Whereas, closer spacing effect on yield and qualitydue competition within the crop plants for nutrient, air and water.So that, optimum plant geometry as per the crop geometry (non-monetary inputs)exhibits higher yield of fennel.A study found that 45 cm row spacing resulted in 7.9% rise in umbels per plant and 4.0% rise in umbellates per umbel compared to 60 cm row spacing (Al-Dalain*et al.* 2012). Climate change is inevitable so that terrestrial ecosystem and global food security is incessantly threatening. Although, the impacts of climate change on crop yield and the

environment have received much attention in recent years, there are few studies on its implications for the production of high-quality seeds that provide the basic input for food production.The objective of this study to determining the optimum sowing time is to identify the most favorable time for planting cultivars, where the prevailing environmental conditions are conducive to thegermination and vitality of the plants under North Gujaratagro-climatic condition.

MATERIALS AND METHODS

Site Specifications

The present field study was conducted at Agronomy InstructionalFarm of C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar, Gujarat during 2015-16.The site is located in North-east zone of Gujarat which comes under sub-tropical monsoon region having 24°/19' North latitude and 72°/19' East longitude with an elevation of 154.52 meters above mean sea level.

Weather

The weather condition of experiment conducted field is warm and moderately humid. Winter is fairly cold and dry while summer is quite hot and dry. The December and January are the coldest months of winter season with 12.2°C average temperature. Whereas, May is the hottest month of the year with 40.8°C average temperature.The south-west monsoon commences by the middle of June and retreats by the middle of September. The annual average rainfall is about 620.9 mm with about 27 rainy days.

Sampling and analyses

Before the commencement of experiment,collection of soil samples randomly from different spots at a depth of 0-15 and 15-30 cm. The composite soil sample for each depth was prepared and analysed for physical and chemical properties of soil. After the soil analysis in laboratory,it shows that the pH of the experimental soil was neutral in nature (7.4) having

electrical conductivity of 0.10 ds/m(Rechard, 1954). The determination of organic carbonby Walkely and Black (1947),available nitrogenby Subbaiah and Asija (1956), available phosphorus by Olsen *et al*. (1954)and available potassium by Jackson, 1973and it indicated that soil content was 0.17 %, 159 kg/ha, 39 kg/ha and 271 kg/ha oforganic carbon, available nitrogen, available phosphorus and available potassium, respectively.

Experimental setup

The experiment was laid out in spilt plot design with threesowing times (D_1:3rdweek of October, D_2:1stweek of Novemberand D_3: 3rdweek of November)as main plot, threevarieties (V_1: Gujarat Fennel-2, V_2: Gujarat Fennel-11 and V_3: Gujarat Fennel-12) and twospacings (S_1: 45 cm and S_2: 60 cm) insub plot in *rabi* season at Agronomy InstructionalFarm, S. D. Agricultural University, Sardarkrushinagar during 2015-16in split plot design having eighteen treatment combinations with fourreplications. The experimental field was prepared as per the requirement of field and crop by ploughing, harrowing and planking were done with help of tractor to obtain a good tilth. As per plan of experimental design, the bunds and field channels were prepared and levelled the plots with the help of labours. The fennel was fertilized with recommended dose of fertilizer (90: 30: 30 NPK Kg/ha). By keeping uniform seed rate of 4.5 kg per hectare,the required quantity of seeds of fennel varieties were taken for swing.Irrespective of treatments, thinning of extra plant was done 20 DAS by hand pulling to maintain the intra-row spacing of 15 cm. All the need based agronomic practices were carried out for the better crop growth and development. The aphid and severedisease *viz.*, Rumularia blight was observed during the life cycle of crop, adequate and timely plant protection measures were taken by spraying recommended pesticide (Dimethoate) and fungicide (Dithane-M-45) in the crop.

Observation recorded

For recording various growth and yield attributesfive plants were selected from each plot.

Estimation of protein content

The nitrogen was estimated from seed by adopting the micro Kjeldahl's (Jackson, 1967).For the calculation of protein content in seed by using formula given by Bhuiya and Chaudhary, 1974.

$$\text{Protein content (\%)} = \text{Nitrogen content (\%)} \times 6.25$$

Estimation of volatile oil content

By using steam distillation method (AOAC, 1970) the volatile oil content was determined. The volume of oil is converted into percentage by using following given formula.

$$\text{Volatile oil (\%)} = \frac{\text{Volume of oil (ml)}}{\text{Wight of seed sample}} x100$$

Estimation of volatile oil yield

By using given formula, the volatile oil yield (kg/ha) was calculated

$$\text{Volatile oil yield (kg/ha)} = \frac{\text{Volatile oil content (\%)} \times \text{yield (kg/ha)}}{100}$$

Statistical analysis

The experimental data *i.e.*critical difference (CD)analysis of variance(ANOVA) was worked out as described by Panse and Sukhatme (1985), Cochran and Cox (1957) and Gomez and Gomez (1984), respectively.

RESULTS AND DISCUSSION

Impact of time of sowing

The data shown in Table 1 and 2 that early sown crop *i.e.* 3rd week of October recorded significantly higher plant height (155.68 cm),total number of branches per (18.28), number of umbels(20.39) per plant and umbellates per umbel (19.78),1000-seed weight (8.00 g), seed yield (1423 kg/ha), productivity per day (8.37 kg/ha/day), quality attributes *viz.*, oil (1.59

%)and protein (13.96 %)content,oil yield (24.20 kg/ha)as well as economics in term of gross(108728 ₹/ha)and net (64065 ₹/ha)realization, cost of cultivation (44663₹/ha), net income per day (377₹ ha/day)and benefit cost ratio of 2.43as compared over late sowing *i.e.*1st week of November and 3rd week of November.Whereas, seed yield, productivity per day and protein content were statistically at par with 1st week of November. The maximum seed yield was recorded in 3rd week of Octoberwas 7.7 and 31.8 per cent over late sowing *i.e.*1st week of November and 3rd week of November, respectively.Favourable climatic condition throughout the crop season under early sown crop enhanced growth and yield attributing character. These are the important growth and yield components, which showed significantly positive correlation with seed yield and consequently net profit. The conversion of primary fatty acids metabolitesresulted in increased volatile oil content in seed and important role in synthesis of different amino acid (building blocks of protein) that might have resulted in higher protein content.Late sowing suppressed initial vegetative growth and ultimately poor reproductive growth and yield. Moreover, high temperature at reproductive stage brought forced for early maturity consequently reduced yieldand oil content of seed. These results are with line of work reported by Singh *et al.* (2006), Bagari *et al.* (2010), Selim *et al.* (2013), Moosavi*et al.* (2014), Meena *et al.* (2015) Babaee*et al.* (2017), Shambhu*et al.* (2019), Sharma*et al.* (2019) and Singh*et al.* (2019).

Impact of variety

Significantly tallestplant (153.16cm), number of branches (18.10) and number umbels (20.42) per plant, umbellates per umbel (20.62), 1000-seed weight (8.01g), seed yield (1411kg/ha), productivity per day (8.75kg/ha/day), quality attributes *viz.*, oil (1.53%), and protein (14.52%) content,oil yield (24.22kg/ha) as well as economics in term of gross (107853₹/ha) and net (63556₹/ha)realization, total cost of cultivation (44296₹/ha), net income per day (393₹/ha/day)and benefit cost ratioof 2.42were recorded under GF-12over

GF-11 and GF-2 (Table 1 and 2).However, productivity per day and volatile oil content were statistically at par with GF-11. The fennel variety GF-12 expressed its superiority might be due to genetic potential, favourable of soil and climatic conditions and optimum space available for exploitation of highergrowth, yield, oil and protein content and there by remuneration. Similar results were in consonance with those of Malik *et al.* (2009), Singh *et al.* (2009), SDAU (2010), Meena and Singh (2013) and Sengupta *et al.* (2014).

Impact of spacing

Appreciable effect of different spacing on growth, yield and quality but did not exhibit a significant influence on test weight, volatile oil content and protein content. Significantly the tallestplant (151.89cm), total number of branches(17.13) and umbels (19.63)per plant, umbellates per umbel (19.09), seed yield (1346kg/ha), productivity of 8.34kg/ha/day, quality attributes *viz.*, oil yield of 21.67kg/haas well as economics in term of gross (102883₹/ha) and net (58586₹/ha)realization, total cost of cultivation (44296₹/ha), net income per day (362₹/ha/day)and benefit cost ratio of 2.31were recorded under 45 cmover60 cm (Table 1 and 2). The optimum inter and intra row space available for individual plants and adequate plants per unit area as per the plant geometry might have resulted in better utilization of resourcesviz.,moisture, carbon dioxide,space, nutrients and radiant energy to improve vegetative growth in terms of higher plant height and total number of branches per, yieldin term of number of umbels and umbellates per umbel per plant and consequently increase net profit. These findings are in close proximity with Yadav *et al.* (2000), Amin *et al.* (2005), Singh *et al.* (2009),Shambhu*et al.* (2019), Choudhary*et al.* (2021)and Rajeshwari*etal.* (2022).

Interaction effect

Interaction effect between sowing time and spacing was showed its significance onplant height and seed yield (Table 3).Significantly the tallestplant with higherseed yield

was recorded under treatment combination ofD_1S_1 (3^{rd} week of October with 45 cm spacing) was found at par with treatment combinations of D_2S_1 and D_1S_2.

Conclusion

The impact of climate change on agriculture poses a significantthreat globally, as it exacerbates both biotic and abiotic stresses that affect fennel production.In order to produce more food and maintain the current pace of food production, the field experiment conducted at Sardarkrushinagar and it concluded that higher growth, yield, quality as well as net profit can be achieved by sowing the fennel at optimum time *i.e.*3^{rd} week of October. As per adaptability to local climatic conditionsselection of suitable variety *i.e.*GF-12and optimum row spacing as per the plant geometry*i.e.*45 cm under North Gujarat Agro-climatic condition.

ACKNOWLEDGEMENT

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

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.

References

A.O.A.C. (1970). Official methods of Analysis. Association of official Agriculture Chemists, Washington.

Al-Dalain, S. A., Abdel-Ghani, A. H., Jawad, A., Al-Dala'een, Haditha, A and Thalaen. (2012). Effect of planting date and spacing on growth and yield of fennel (Foeniculum vulgare Mill.) under irrigated conditions,*Pakistan Journal Biological Science*, **15**(23):1126-32.

Amin, A.U., Singh, A., Patel, B. S. and 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) [a.] State of Indian Agriculture 2022-23. Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India, New Delhi. pp. 202-205.

Anonymous (2023) [b.] District-wise Area, Production and yield in Gujarat State during 2022-23. Directorate of Agriculture Gujarat State Gandhinagar. pp. 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. pp. 42.

Babaee, M., Miri, R. and Khaleghi, E., (2017). Essential oil composition of fennel (*Foeniculum vulgare* Mill.) at different sowing dates. *Industrial Crops and Products*, 108: 504-508.

Bagari, S., Singh, P. P., Naruka, I. S., Rathore, S. S. and 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.

Bhuiya, Z.H. and Chaudhary, S.V. (1974). Effect of NPK and Son quality of groundnut. *Asian Journal of Agricultural Science*, **44**(1): 751-754.

Choudhary, M., Shivran, A. C., Lakhran, H., Verma, H.P., Choudhary, S. and Doodhwal, K. (2021). Effect of plant geometry and weed management on growth and yield of fennel (*Foeniculum vulgare* Mill.) under semi-arid conditions of Rajasthan. *Indian Journal of Agronomy*, 66(2):111- 117

Gomez, K. A. and Gomez, A. A.(1984). Statistical procedures for Agricultural Research, Edition 2nd, John Willey, New York, pp: 693.

Jackson, M. L. (1973). Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi. pp. 183-192.

Malik, T. P., Tahlan, S. K. and 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. and 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.

Moosavi, S. G., Seghatoleslami, M. and Ansarinia, E. (2014). Fennelmorphological traits and yield as affected by sowing date andplant density. *International Journal of Bioscience*, 54: 222-229.

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

Panse, V.G. and Sukhatme, P.V. (1985) Statistical Methods for Agricultural Workers. *Indian Council of Agricultural Research Publication*, 87-89.

Rajeshwari, M., Vishwanath, Y. C., Vijayakumar., Narayanapur, B., Prabhakar, I., Vijaymahantesh and Ghandhe, A. R. (2022). Effect of geometry and fertilizer levels on growth and yield of fennel (*Foeniculum vulgare* Mill.) under northern dry zone of Karnataka. *The Pharma Innovation Journal*, **11**(2): 909-912.

Randhawa, G. S., Bains, D. S., Mahajan, V. P. and Singh, K. (1978.) Effect of sowing date and levels of nitrogen on the yield of fennel (*Foeniculum vulgare* Mill.). *Journal of Research, Punjab Agricultural University.***15** (3): 229-235.

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

Safaei, Z., Azizi, M., Davarynejad, G. and Aroiee, H. (2017). The effect of planting seasons onquantitative and qualitative characteristics of black cumin (Nigella sativa L.). *Journal of Medicinal Plants and Byproduct*, 6: 27-33.

S.D.A.U.(2010). Annual Research Report of Seed Spices Research Station, Jagudan, Proposal for release of variety Gujarat Fennel 12 (GF 12) Submitted to the 39th State Seed-committee, 2010, SardarkrushinagarDantiwada Agricultural University, Sardarkrushinagar. pp. 1-13.

Selim, S. M., Ebtsam, M. M. A. Tawfic, M. S. H. and 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. and Naidu, A. K. (2014). Genetic variability study in fennel (*Foeniculum vulgare* Mill.). *International Science Journal*, **1**(1):62-64.

Shambhu, K.C., Meena, A., Haldar, D.K. Patidar and Abdul, R.(2019). Effect of Sowing Time and Plant Geometry on Growth, Yield and Quality of Chandrasur Lepidium sativum L. *International Journal of Current Microbiology and Applied Sciences*,**8**(3): 1985-1991.

Sharma, K. D., Choudhary, O. P. and Bhatia, S. (2019). Impact of sowing date on growth, yield and essential oil content of fennel (Foeniculum vulgare Mill.) under semi-arid condition of northwestern India. *Journal of Spices and Aromatic Crops*, **28**(1): 65-70.

Singh, R. K., Singh, B. and Singh, A. K. (2019). Effect of sowing date on growth, yield and oil content of fennel (*Foeniculum vulgare* Mill.). *Journal of Pharmacognosy and Phytochemistry*, **8**(4): 4394-4398.

Singh, S. K., Tripathi, S. M. and 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., Butter, G. S. and 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.

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

Yadav, A. C., Yadav, J. S. and Dhankhar, O. P. (2000). Effect of row and plant spacing on growth and yield of fennel (*Foeniculum vulgare* Mill.) c.v. PF-35. In: Spices and aromatic: challenges and opportunities in the new century. Centennial Conference on Spices and Aromatic plants, 20-23 September, 2000, Calicut (pp. 199-201). Indian Society for Spices, Calicut.

Zhang, Z., Li, Y., Xinguo, C., Wang, Y., Niu, B., Li Liu, D., and Meng, Q. (2023). Impact ofclimate change and planting date shifts on growth and yields of double cropping rice insoutheastern China in future. *Agricultural Systems* 205: 103581.

Tamboli, Y. A., A. U. Amin, J. K. Patil and Patel, U.V. 2020. Yield, Quality and Economics of Rabi Fennel (Foeniculum vulgare Mill.) as Influenced by Different Time of Sowing, Variety and Spacing. Int.J.Curr.Microbiol.App.Sci. 9(04): 2358-2366.

doi: https://doi.org/10.20546/ijcmas.2020.904.283

Table 1: Influence of time of sowing, variety and spacing on growth, yield and quality parameters of *rabi* fennel

Treatments	Plant height (cm)	Total number of branches per plant	Number of umbels per plant	Number of umbellates per umbel	Test weight (g)	Seed yield (kg/ha)	Productivity per day (kg/ha/day)	Volatile oil content (%)	Volatile oil yield (kg/ha)	Protein content (%)
Times of sowing (D)										
D_1: 3rd week of October	155.68	18.28	20.39	19.78	8.00	1423	8.37	1.59	24.20	13.96
D_2 : 1st week of November	151.18	16.95	18.81	18.71	7.64	1321	8.20	1.47	20.29	13.73
D_3 :3rd week of November	141.44	14.87	17.53	17.65	6.78	1079	7.14	1.39	16.02	13.08
S.Em.±	3.11	0.16	0.52	0.41	0.16	33	0.21	0.02	0.46	0.14
C.D. at 5%	10.76	0.54	1.80	1.43	0.54	115	0.72	0.06	1.61	0.49
Varieties (V)										
V_1 : GF-2	146.09	15.64	17.65	17.15	6.94	1138	7.06	1.44	16.20	12.89
V_2 : GF-11	149.05	16.38	18.66	18.37	7.46	1272	7.90	1.48	20.09	13.36
V_3 : GF-12	153.16	18.10	20.42	20.62	8.01	1411	8.75	1.53	24.22	14.52
S.Em.±	1.58	0.13	0.37	0.29	0.14	25	0.16	0.02	0.39	0.11
C.D. at 5 %	4.50	0.38	1.06	0.83	0.39	72.36	0.45	0.05	1.10	0.31
Spacings (S)										
S_1 : 45 cm	151.89	17.13	19.63	19.09	7.51	1346	8.34	1.48	21.67	13.68
S_2 : 60 cm	146.99	16.28	18.19	18.34	7.44	1202	7.47	1.48	18.67	13.50
S.Em.±	1.29	0.11	0.30	0.24	0.11	21	0.13	0.01	0.31	0.09
C.D. at 5%	3.67	0.31	0.87	0.68	NS	59.08	0.37	NS	0.90	NS

Table 2: Influence of sowing time, variety and spacing on economics of *rabi* fennel

Treatments	Gross realization (₹/ha^{-1})	Total cost of cultivation (₹/ha^{-1})	Net realization (₹/ha^{-1})	Net income per day (₹/ha/day)	BCR
Times of sowing (D)					
D_1	108728	44663	64065	377	2.43
D_2	101049	44663	56386	351	2.25
D_3	82596	43563	39032	259	1.89
Varieties (V)					
V_1	87164	44296	42867	265	1.96
V_2	97356	44296	53059	328	2.19
V_3	107853	44296	63556	393	2.42
Spacings (S)					
S_1	102883	44296	58586	362	2.31
S_2	92032	44296	47736	296	2.07

Note: See Table 1 for treatment details.

Table 3: Interaction effect of time of sowing and spacing

Treatments	Plant height (cm)		Seed yield (kg/ha)	
Spacings (S)	**S_1**	**S_2**	**S_1**	**S_2**
Times of sowing (D)				
D_1	157.73	153.64	1549	1296
D_2	156.90	145.46	1377	1265
D_3	141.03	141.86	1111	1046
S.Em.±	2.73		43.96	
C.D. at 5%	7.80		125	

Note: See Table 1 for treatment details.

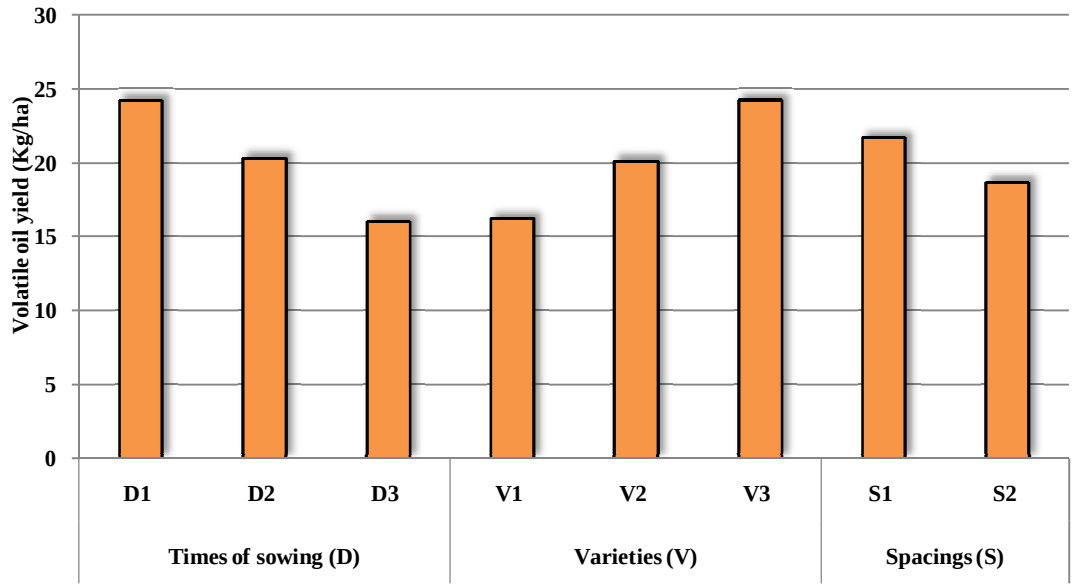

Fig. 1 : Effect of times of sowing, varieties and spacings on volatile oil yield of *rabi* fennel.

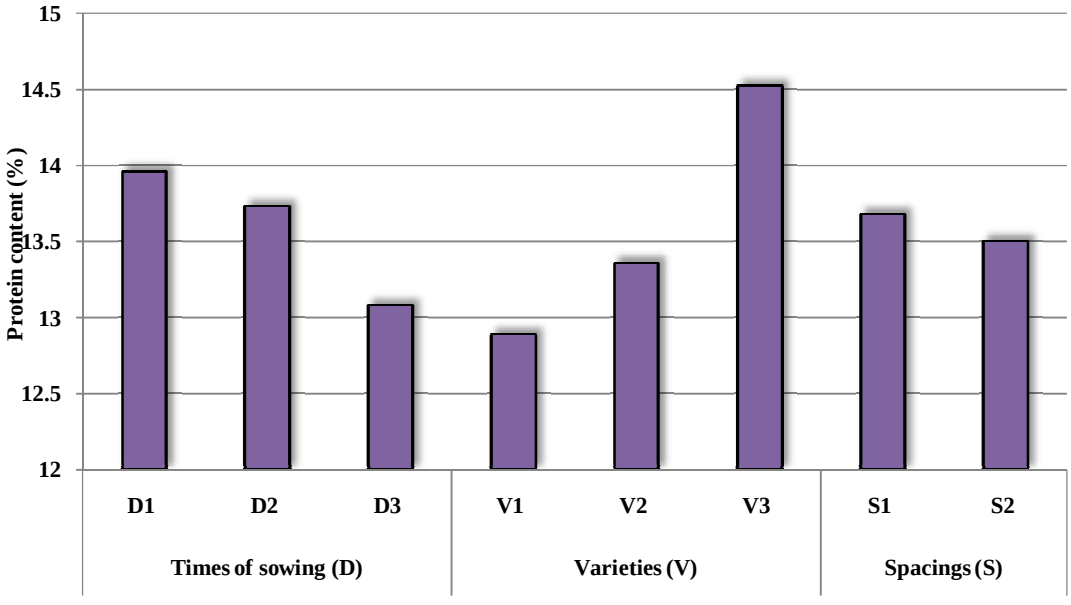

Fig. 2: Effect of times of sowing, varieties and spacings on protein content of *rabi* fennel.

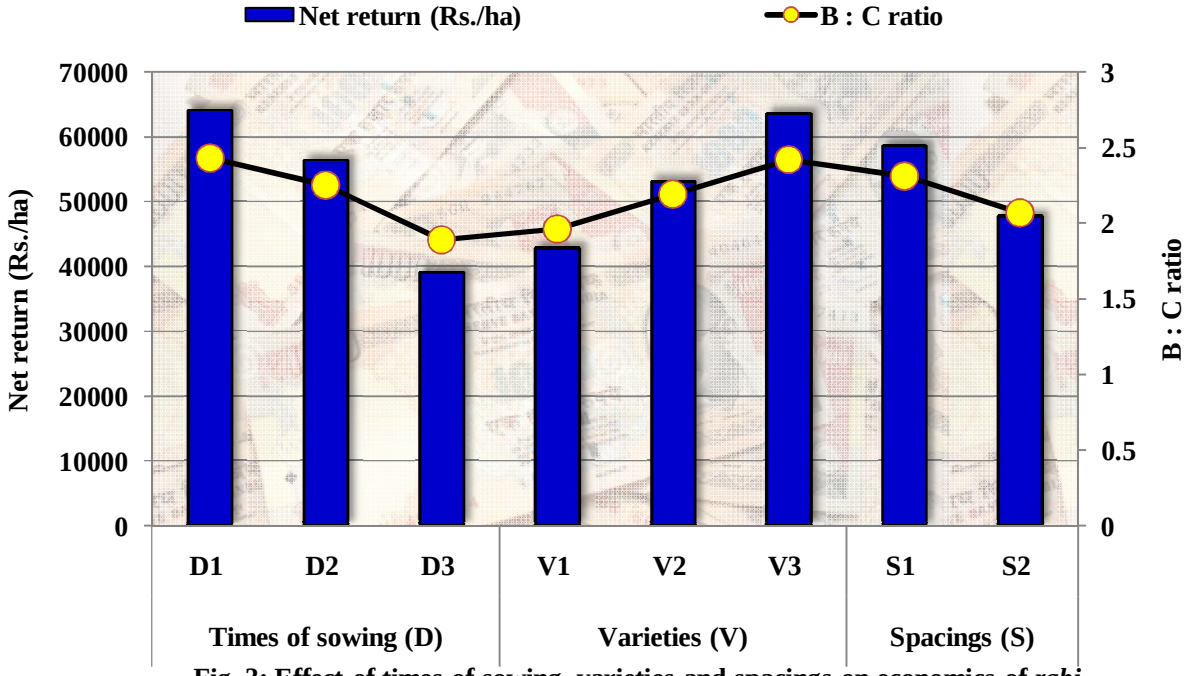

Fig. 3: Effect of times of sowing, varieties and spacings on economics of *rabi* fennel