

# Influence of different nitrogen levels and spacing on seed yield and economics of fennel (*Foeniculum vulgare* Mill.)

## ABSTRACT

The present study entitled, "Influence of nitrogen levels and spacing on seed yield and economics of fennel (*Foeniculum vulgare* Mill.)" was conducted during the *Rabi* season of 2021-22 with fennel variety HF-143 using four different nitrogen levels (0, 25, 50 and 75 kg ha<sup>-1</sup>) and three-row to row spacing (30 x 20 cm, 45 x 20 cm and 60 x 20 cm). Sowing of crop was done on 30<sup>th</sup> October, 2021 in factorial RBD and harvesting on 10<sup>th</sup> May, 2022. The yield parameters *i.e.*, number of umbels per plant, number of umbelletes per umbel, seeds per umbels and seed yield (per plot and hectare) were recorded with three replication of each treatment. The economics of each treatment was also calculated. The result revealed that the treatment combination of 50 kg N ha<sup>-1</sup> with 45 x 20 cm spacing was found to be best for obtaining higher seed yield. Fertilizing the fennel crop with 50 kg ha<sup>-1</sup> nitrogen level and sowing at 45 x 20 cm is economical to obtain high seed yield. Though seed yield increase with increase nitrogen fertilizer dose but the rise in value of seed yield from 50 to 75 kg N ha<sup>-1</sup> was found non- significant. From the present study, it can be concluded that fennel crop produced higher seed yield (18.23 q ha<sup>-1</sup>), maximum net return (Rs. 1,14,670ha<sup>-1</sup>) and B:C (2.71) at 50 kg N with 45 x 20 cm spacing under semi-arid, subtropical condition in sandy loam soil of Haryana.

*Keywords: Fennel, nitrogen, spacing, seed yield and economics*

## INTRODUCTION

Fennel is one of the most important seed spice crop natives to the Southern Europe and Mediterranean region (1). It is the annual herbaceous plant belonging to family Umbelliferae (Apiaceae). Fennel is cultivated for its economic, aromatic and medicinal value. The dried seeds contribute to pleasantly aromatic spice that is much used in stews, cuisine, sweet breads, sausages and cakes (2). Mature fennel seeds are used as flavoring agents in food products such as pickles, liqueurs and cheese (3). Despite of culinary and industrial uses fennel seeds also have medicinal importance due to presence of various chemicals including trans anethol, d-2 fenchone, 2-pinene, foenicullin, camphene, d-2 phellandrene, foenicullin, dipentenes, tri terpinene. Fennel seeds are estrogenic having digestive, stimulative, appetizing and carminative properties chewed as a remedy to prevent bad smell of breath and also used in cough, flatulence, dysentery and diarrhoea (4). Although the climatic conditions in India are favourable for fennel cultivation but it is grown in a limited area and till date it is an underutilized seed spice crop. This limited cultivation is due to less attention given in past for its cultural aspects and thus the lack of knowledge among farmers about the cultural requirements for effective cultivation. Nitrogen fertilizer and spacing are two important factor which determines the overall growth, yield and economics of this crop

Among the various factors which increase yield on a per unit area basis, the application of nitrogen fertilizer is considered to be the most important one (5). Nitrogen present in plants in organic form: nucleic acid, vitamins, hormones, coenzymes and pigments.

Application of nitrogen not only increases seed yield but can also improve oil content (6). Nitrogen application had a positive effect on plant height and seed yield of fennel (7& 8). Spacing is also an important factor determining growth and yield. Adjustment in planting pattern creates favourable environmental conditions for better performance of all the physiological processes in plants and thus, provide greater opportunity to maximum yield. The wider spacing increases yield and growth of fennel while closer spacing increase competition within the crop plant results in poor growth and yield by determining the micro environment in the field. Proper optimization of this factors can lead to higher yield by favourably affecting absorption of nutrients and exposing plants to light (9). As the fennel seeds are gaining importance due to its commercial, medicinal and industrial value, it is very necessary to cope up increasing demand with increase production and this can be achieved by using proper agronomic practises. Therefore, a study was conducted to check the effect of nitrogen levels and spacings on seed yield and economics of fennel.

## **MATERIALS AND METHODS**

The present experiment was carried out during *Rabi* season 2021-2022 at Research Farm, Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The experimental field was located at an elevation of 215.2 meters above mean sea level in the subtropics with coordinates of 29° 10' North latitude and 75 ° 46' East longitudes. The experiment consists of four nitrogen levels *viz.*, 0, 25, 50 and 75 kg ha<sup>-1</sup> and three different row spacings *viz.*, 30, 45 and 60 cm. The treatments were evaluated in factorial RBD with three replications. Sowing of the fennel variety HF-143 was done on 30<sup>th</sup> October, 2021, half the dose of nitrogen was supplied as basal dose and rest half dose as top dressing on 45 days of sowing. All recommended agronomic practices were followed timely for successful raising the crop. Harvesting of crop was done after full maturity on 10<sup>th</sup> May, 2022 and after sun drying for 4 to 5 days in the field threshing was done. Different yield parameters *viz.*, number of umbels /plant, umbellate/umbel, seeds/ umbel, seed yield/plot, seed yield/ha were recorded on ten randomly selected plants. Observational plants were tagged from each plot. Boarder rows plants were avoided for recording observations. The average of different recorded observations was subjected to statistical analysis by Panse and Sukhatme (10).

## **RESULTS AND DISCUSSION**

### **Effect of nitrogen fertilizer level on yield attributes and seed yield**

Nitrogen fertilizer significantly affected the yield attributes *viz.* number of umbels per plant, umbellate per umbel, seeds per umbel and ultimately the seed yield. The inflorescence of fennel is called umbel. Umbel contains umbellate where seed setting takes place. The numbers of umbel were directly responsible for a good yield. More umbel per plant ensures more seed yield. Among different nitrogen levels tried, number of umbels per plant (36.94) were observed significantly maximum with nitrogen applied at 75 kg ha<sup>-1</sup> which were statistically at par with nitrogen supplied at 50 kg ha<sup>-1</sup> (36.23) whereas, the minimum number of umbels per plant were recorded with control (21.10). It might be due to the greater availability of nutrients to the plant so that it could develop a more significant number of branches and reproductive structures due to which a maximum number of umbels were produced on the plant. It also proved the finding of Azizi *et al.* and Nath *et al.* (11&12) in ajowain and Tehlan *et al.* (13) in coriander. Whereas, Kucha *et al* (14) observed the significant maximum number of umbels per plant in fennel on the application of 120 kg N ha<sup>-1</sup>. As the number of umbellate per umbel depends on number of umbels per plant so significantly maximum number of umbellate per umbel was recorded at 75 kg N ha<sup>-1</sup> (26.40), closely followed by 50 kg N ha<sup>-1</sup> (26.11). Whereas, significantly the lowest value was observed under control treatment. The number of umbellets per umbel increased with an

increase in nitrogen dose. Similarly, Mehta *et al.* and Singh and Amin (15 & 16) observed an increase in the number of umbellets per umbel with an increased nitrogen dose of up to 120 kg N ha<sup>-1</sup> in fennel crop. It might be due to the greater availability of photosynthates, metabolites and nutrients for the development of reproductive structures as nitrogen played an essential role in chlorophyll synthesis, which is the main absorber of light energy needed for photosynthesis and thus, increased photosynthates production and translocation in plant. High nitrogen levels had positively affected seeds per umbel up to the moderate dose of application. The maximum number of seeds per umbel was recorded at the highest nitrogen dose among all treatments, *i.e.*, at 75 kg N ha<sup>-1</sup> (533.40), closely followed by nitrogen supplied at 50 kg ha<sup>-1</sup> (526.07) which were statistically at par. Similar results were recorded by Mohammad *et al.* and Raj and Thakral (17 & 18) in fennel. The greater availability of nutrients in the root zone led to increased metabolic activity at the cellular levels and thus, increased the number of seeds per umbel in fennel. Also, an increase in a number of seeds per umbel in fennel may be attributed to improved number of umbellets per umbel and seeds per umbellet which ultimately resulted in higher seeds per umbel. The plot having highest yielding plants will subsequently possess highest yield per plot. The data presented in Table 2 showed that seed yield per plot was significantly influenced by nitrogen levels. Seed yield per plot (0.946 kg) was recorded significantly maximum with the application of 75 kg ha<sup>-1</sup> of nitrogen which was statistically at par with nitrogen supplied at 50 kg ha<sup>-1</sup> (0.943 kg), whereas the minimum seed yield per plot was recorded with control (0.733 kg). Seed yield per hectare means, productivity enhanced with increased nitrogen levels. The results of this investigation showed that seed yield was significantly influenced with nitrogen levels. Maximum seed yield was recorded on the application of 75 kg N ha<sup>-1</sup> (17.55 q ha<sup>-1</sup>) closely followed by nitrogen supplied at 50 kg ha<sup>-1</sup> (17.54 q ha<sup>-1</sup>). The higher seed yield in fennel may be attributed to improved yield components, which ultimately resulted in higher yield as growth and yield aspects showed a significantly positive correlation with seed yield. Significant increase in seed yield under higher nitrogen levels was due to the formation of strong sinks and source activity. The present findings are in close agreement with the results obtained by Bhardwaj and Kumar (19) and Meena *et al.* (20) in fennel.

#### **Effect of spacing on yield attributes and seed yield**

Row Spacing significantly affected the yield attributes *viz.* number of umbels per plant, umbellate per umbel, seeds per umbel and ultimately the seed yield. From the present study it can be concluded that number of umbels per plant are significantly affected by row spacing. Significantly maximum number of umbels /plants were recorded maximum at 60 x 20 cm spacing (33.28) statistically at par with 45 x 20 cm (32.38). In fennel, Waskela *et al.* (21) and Jakhar *et al.* (22) recorded similar results and found that wide spacing resulted in higher nutrient absorption, profuse branching and greater biomass accumulation per plant. The profuse branching led to the more flowering and optimum supply of metabolites due to the increase in biomass per plant might have helped in the retention of a greater number of umbels per plant. At the same time, Singh and Amin (2015) (16) and Tamboli *et al.* (2020) (23) suggested that the spacing of 45 x 20 cm gave significantly more umbels per plant in fennel. Number of umbelletes per umbel depend on the growth and nutrient status of plant and significantly affected by spacing. Number of umbellets per umbel were noticed significantly maximum at 60 x 20 cm spacing (24.54) closely followed by 45 x 20 cm (24.36), while the minimum number of umbellets per umbel were observed at 30 x 20 cm (23.85) spacing. Similar results were observed by Waskela *et al.* (21) and Jakhar *et al.* (22) in fennel. Whereas, Singh and Amin (2015) observed the maximum number of umbellets per umbel at 45 x 20 cm spacing in fennel and stated that the vigorous vegetative growth in the adequate space increased the biomass per plant to appropriate supply of metabolites and, consequently a maximum number of umbellets per umbel. The number of seeds per umbel

has a positive correlation with metabolites production and source and sink relation. Significantly maximum number of seeds per umbel was recorded at 60 x 20 cm spacing (448.37) statistically at par with 45 x 20 cm (441.08). In contrast, the minimum number of seeds per umbel was observed at 30 x 20 cm (414.74) spacing. Similar results were recorded by Waskela *et al.* (21) it might be due to the robust vegetative growth and higher biomass accumulation in widely spaced plants led to an increased supply of metabolites towards a reproductive structure that helped to get maximum seeds per umbel in fennel. Maximum seed yield (per plot and per hectare) is the ultimate goal of any farmer and it depends directly on growth and yield attributes. Seed yield is affected significantly by spacing as a factor of competition among plants and the spacing which gives maximum yield is the optimum spacing. Seed yield was observed significantly maximum at 45 x 20 cm spacing (16.85 q ha<sup>-1</sup>) followed by 60 x 20 cm (16.29 q ha<sup>-1</sup>). Similar results were recorded by Singh and Amin (16) and Tamboli *et al.* (23) in fennel. This might be due to the availability of optimum space for individual plants which has resulted in better utilization of resources *viz.*, space, nutrients, moisture, carbon dioxide and radiant energy to improve vegetative growth, reproductive growth and seed yield. Also, close spacing led to competition among plant, while wider spacing led to low plant population and both conditions resulted in lower seed yield. Thus, optimum spacing is best suited for seed yield.

#### **Interaction effect of nitrogen levels and spacing**

Interaction effects of nitrogen levels and spacing on number of umbels per plant and seed yield (per plot and per hectare) of fennel was found significant whereas non-significant on the number of umbellets per umbel and seed per umbel. Significantly maximum number of umbels per plant were found at treatment combination of (T<sub>4</sub>S<sub>3</sub>) *i.e.*, nitrogen applied at 75 kg ha<sup>-1</sup> under 60 x 20 cm (38.30) spacing, which were statistically at par with T<sub>4</sub>S<sub>2</sub> (37.86), T<sub>3</sub>S<sub>3</sub> (37.67) and T<sub>3</sub>S<sub>2</sub> (37.12). Whereas, the minimum number of umbels per plant were recorded with the treatment combination of T<sub>0</sub>S<sub>1</sub> (18.22). Interaction effect was found non-significant for a number of umbellets per umbel and seed per umbel. However, the maximum number of umbellets per umbel (26.68), seeds per umbel (550.42) were found at the treatment combination of (T<sub>4</sub>S<sub>3</sub>) *i.e.*, nitrogen applied at 75 kg ha<sup>-1</sup> under 60 x 20 cm spacing followed by T<sub>4</sub>S<sub>2</sub> 26.52 and 543.47 respectively. Whereas, the minimum number of umbellets per umbel were recorded with the treatment combination of T<sub>0</sub>S<sub>1</sub> 20.31 and 270.15 respectively. Interaction effect of nitrogen levels and spacings on seed yield (per plot and per hectare) was found significant. Maximum seed yield (per plot and per hectare) was obtained with the treatment combination of T<sub>4</sub>S<sub>2</sub> (0.980 kg) and (18.24 q ha<sup>-1</sup>), *i.e.*, nitrogen applied at 75 kg ha<sup>-1</sup> under 45 x 20 cm spacing which was statistically at par with T<sub>3</sub>S<sub>2</sub> (0.977 kg) and (18.23 q ha<sup>-1</sup>). In comparison, minimum seed yield per plot was recorded with treatment combination of T<sub>0</sub>S<sub>1</sub> (0.647 kg) and (12.05 q ha<sup>-1</sup>), *i.e.*, at control under 30 x 20 cm spacing.

#### **ECONOMICS**

While taking a decision regarding the adoption of new technology, economics is the major consideration of the farmer. A technology proves to be fruitful to a farmer if it minimizes his cost and maximizes his return. This can be estimated using the concept of B:C, which is the ratio of gross return to the total cost. Any practice with a higher B:C would be more advantageous over others. The data presented in Table 4 depicted the economics of the fennel. Among different treatments, the highest cost of cultivation (Rs. 67945 ha<sup>-1</sup>) was incurred in fennel sown at higher nitrogen levels, *i.e.*, 75 kg ha<sup>-1</sup> under different spacing. Among different treatments, the highest gross return of Rs. 182420 ha<sup>-1</sup> was obtained at 75 kg N ha<sup>-1</sup> with 45 x 20 cm spacing closely followed by 50 kg N ha<sup>-1</sup> with spacing of 45 x 20 cm (Rs. 182315 ha<sup>-1</sup>). While comparing the net returns and benefit-cost ratio, the highest net return (Rs. 114670 ha<sup>-1</sup>) and B: C ratio (2.70) were reported at 50 kg N ha<sup>-1</sup> under 45 x 20 cm

spacing closely followed by the treatment 75 kg N ha<sup>-1</sup> with 45 x 20 cm spacing (Rs. 114475 ha<sup>-1</sup> and 2.68).

## CONCLUSION

Nitrogen and spacing are the two major factors required for the good production or yield of any crop. The increase seed yield ultimately depends on good yield contributing characters, which results from proper dose of fertilizers. To standardize the level of nitrogen application and row spacing, the study was conducted. From the result of the study, it could be concluded that treatment T<sub>3</sub>S<sub>2</sub> was found to be best for obtaining higher seed yield. Fertilizing the fennel crop with 50 kg ha<sup>-1</sup> nitrogen level and sowing at 45 x 20 cm is economical to obtain high seed yield. Though seed yield increase with increase nitrogen fertilizer dose but the rise in value of seed yield from 50 to 75 kg N ha<sup>-1</sup> was found non-significant. Only numerical difference was observed in value, statistically they were at par and it might be due to environmental factors. Thus, as per the present findings 50 kg nitrogen level and 45 x 20 cm spacing was observed to be most remunerative for fennel cultivation in semi-arid, subtropical condition in sandy loam soil of Haryana.

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**Table 1: Different treatment combinations of nitrogen levels and spacing**

Treatments	Description
T <sub>1</sub> S <sub>1</sub>	Nitrogen @ 0 kg ha <sup>-1</sup> under 30 x 20 cm spacing
T <sub>1</sub> S <sub>2</sub>	Nitrogen @ 0 kg ha <sup>-1</sup> under 45 x 20 cm spacing
T <sub>1</sub> S <sub>3</sub>	Nitrogen @ 0 kg ha <sup>-1</sup> under 60 x 20 cm spacing
T <sub>2</sub> S <sub>1</sub>	Nitrogen @ 25 kg ha <sup>-1</sup> under 30 x 20 cm spacing
T <sub>2</sub> S <sub>2</sub>	Nitrogen @ 25 kg ha <sup>-1</sup> under 45 x 20 cm spacing
T <sub>2</sub> S <sub>3</sub>	Nitrogen @ 25 kg ha <sup>-1</sup> under 60 x 20 cm spacing
T <sub>3</sub> S <sub>1</sub>	Nitrogen @ 50 kg ha <sup>-1</sup> under 30 x 20 cm spacing
T <sub>3</sub> S <sub>2</sub>	Nitrogen @ 50 kg ha <sup>-1</sup> under 45 x 20 cm spacing
T <sub>3</sub> S <sub>3</sub>	Nitrogen @ 50 kg ha <sup>-1</sup> under 60 x 20 cm spacing
T <sub>4</sub> S <sub>1</sub>	Nitrogen @ 75 kg ha <sup>-1</sup> under 30 x 20 cm spacing
T <sub>4</sub> S <sub>2</sub>	Nitrogen @ 75 kg ha <sup>-1</sup> under 45 x 20 cm spacing
T <sub>4</sub> S <sub>3</sub>	Nitrogen @ 75 kg ha <sup>-1</sup> under 60 x 20 cm spacing

**Table 2: Influence of nitrogen levels and spacing on yield parameters of fennel**

Treatments	Umbels per plant	Umbellets per umbel	Seeds per umbel	Seed yield per plot (kg)	Seed yield per hectare (q/ha)
T <sub>1</sub> : Control	21.10	20.76	282.93	0.73	13.67
T <sub>2</sub> : 25 kg/ha	30.61	23.71	396.53	0.83	15.59
T <sub>3</sub> : 50 kg/ha	36.23	26.11	526.07	0.94	17.54
T <sub>4</sub> : 75 kg/ha	36.94	26.40	533.40	0.95	17.55
Mean T	31.23	24.24	434.73	0.86	16.08
SE (m)	0.35	0.12	3.71	0.002	0.02
CD at 5%	1.05	0.37	10.05	0.005	0.07
S <sub>1</sub> : 30 × 20 cm	28.04	23.85	414.74	0.81	15.13
S <sub>2</sub> : 45 × 20 cm	32.38	24.36	441.08	0.90	16.85

<b>S<sub>3</sub> : 60 × 20 cm</b>	33.28	24.54	448.37	0.88	16.29
<b>Mean S</b>	31.23	24.24	434.73	0.86	16.08
<b>SE (m)</b>	0.31	0.10	3.21	0.001	0.02
<b>CD at 5%</b>	0.91	0.32	9.48	0.004	0.06

**Table 3: Interaction effect of nitrogen levels and spacing on yield and yield parameters of fennel**

<b>Treatments</b>	<b>Umbels per plant</b>	<b>Umbellets per umbel</b>	<b>Seeds per umbel</b>	<b>Seed yield per plot (kg)</b>	<b>Seed yield per hectare (q/ha)</b>
<b>T<sub>1</sub>S<sub>1</sub></b>	18.22	20.31	270.15	0.65	12.05
<b>T<sub>1</sub>S<sub>2</sub></b>	21.86	20.87	285.62	0.80	14.75
<b>T<sub>1</sub>S<sub>3</sub></b>	23.23	21.10	293.02	0.76	14.21
<b>T<sub>2</sub>S<sub>1</sub></b>	25.36	23.36	381.00	0.80	14.87
<b>T<sub>2</sub>S<sub>2</sub></b>	32.67	23.81	400.85	0.87	16.20
<b>T<sub>2</sub>S<sub>3</sub></b>	33.81	23.98	407.73	0.84	15.70
<b>T<sub>3</sub>S<sub>1</sub></b>	33.90	25.71	501.51	0.91	16.80
<b>T<sub>3</sub>S<sub>2</sub></b>	37.12	26.23	534.39	0.98	18.23
<b>T<sub>3</sub>S<sub>3</sub></b>	37.7	26.41	542.30	0.95	17.61
<b>T<sub>4</sub>S<sub>1</sub></b>	34.67	26.02	506.31	0.90	16.81
<b>T<sub>4</sub>S<sub>2</sub></b>	37.86	26.52	543.47	0.98	18.24
<b>T<sub>4</sub>S<sub>3</sub></b>	38.30	26.68	550.42	0.95	17.63
<b>SE (m)</b>	0.62	0.21	6.42	0.003	0.04
<b>CD at 5%</b>	1.82	NS	NS	0.01	0.12

**Table 4: Economics of different treatment combinations of nitrogen levels and spacings**

<b>Treatments</b>	<b>Common cost</b>	<b>Treatment cost</b>	<b>Cost of cultivation</b>	<b>Yield kg/ha</b>	<b>Gross returns</b>	<b>Net returns</b>	<b>B:C</b>
<b>T<sub>1</sub>S<sub>1</sub></b>	67045	0	67045	1205.33	120533	53488	1.80
<b>T<sub>1</sub>S<sub>2</sub></b>	67045	0	67045	1471.33	147633	80088	2.19
<b>T<sub>1</sub>S<sub>3</sub></b>	67045	0	67045	1421.67	142167	75122	2.12
<b>T<sub>2</sub>S<sub>1</sub></b>	67045	300	67345	1487.80	148700	81435	2.20

<b>T<sub>2</sub>S<sub>2</sub></b>	67045	300	67345	1621.00	162100	94755	2.40
<b>T<sub>2</sub>S<sub>3</sub></b>	67045	300	67345	1570.50	157000	89705	2.33
<b>T<sub>3</sub>S<sub>1</sub></b>	67045	600	67645	1680.50	16800	100405	2.48
<b>T<sub>3</sub>S<sub>2</sub></b>	67045	600	67645	1823.15	182315	<b>114670</b>	<b>2.70</b>
<b>T<sub>3</sub>S<sub>3</sub></b>	67045	600	67645	1762.15	176215	108575	2.60
<b>T<sub>4</sub>S<sub>1</sub></b>	67045	900	67945	1681.60	168160	100215	2.47
<b>T<sub>4</sub>S<sub>2</sub></b>	67045	900	67945	1824.20	<b>182420</b>	114475	2.68
<b>T<sub>4</sub>S<sub>3</sub></b>	67045	900	67945	1763.10	176310	108365	2.59

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