Original Research Article

Effect of level of drip irrigation and nitrogen fertigation on yield parameters of fennel

ABSTRACT

In the case of seed spices, the economic yield of seed is an important factor. Plant yield is a complicated trait that is controlled by a variety of circumstances. The present experiment titled "Effect of drip irrigation and nitrogen fertigation on yield parameters of fennel" was conducted during the *Rabi* season for two years during 2021-22 and 2022-23 at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar, Haryana. Which is situated between 29°10' North latitude and 75°46' East longitudes and 215.2 meters above mean sea level. The study was carried out in a Split-split Plot Design comprising 24 treatments and 3 replications having plot size 3 m × 1.35 m and plant spacing 45 cm × 20 cm. The experiment consists of two varieties *viz.* V_1: Hisar Swarup, V_2: HF 143, four Irrigation scheduling*viz.* I_1: 0.6 IW/CPE (Irrigation water/ Cumulative pan evapotranspiration) through the drip, I_2: 0.8 IW/CPE through the drip, I_3: 1.0 IW/CPE through the drip, I_4: 1.2 IW/CPEthrough the drip, three nitrogen levels *viz.* N_1: 20 kg/ha, N_2: 35 kg/ha, N_3: 50 kg/ha. The analysis observed thatthe number of umbels per plant, number of umbellets per umbel, number of seeds per umbel, and the number of seeds per umbellet had a direct positive effect on seed yield per hectare at different levels of drip irrigation and nitrogen fertigation on fennel crop.

Keywords: Seed yield, yield parameters, drip irrigation, nitrogen fertigation, IW/CPE, fennel.

INTRODUCTION

Due to population increase and consumption, and declines in arable land, and other productive units, there is unprecedented pressure on contemporary agriculture and natural resources to meet the growing demand for food. Food security within a sustainable system plays an essential role in poverty reduction, but it poses a significant problem in developing countries. To address this issue, farmers tended to misuse specific inputs, such as chemical pesticides and fertilizers, which have already begun to

impact the soil and environment. To achieve global food security and sustainability, there must be a large increase in food production while reducing the negative environmental effects of agriculture. [1].

Fennel is a very important medical plant because of its pharmaceutical qualities such as carminative, diuretic, anti-inflammatory, antibacterial, antioxidant, and galactagogue. It is used to boost milk production in humans and other animals, as well as to stimulate lactation, lose weight, and live longer. Furthermore, volatile fennel oils are utilized to treat youngsters with flatulent dyspepsia and colic. [2]. It is grown mostly for its seeds, which have an aromatic flavor and pleasant fragrance. It is used in cooking and as a condiment spice. Fennel seeds have a protein content of 9.5%, a fat content of 10%, a fiber content of 18.5%, a carbohydrate content of 42.3%, and a mineral content of 13.4%. [3].

India is the world's greatest producer, consumer, and exporter of spices, and is also known as the "Land of Spices" also the "Home of Spices" [4]. It is primarily grown in Gujarat and Rajasthan, with some quantities grown in Uttar Pradesh, Punjab, Madhya Pradesh, Bihar, Haryana, and Jammu and Kashmir. Gujarat and Rajasthan are the two most important fennel-producing, consuming, and exporting states, accounting for around 96% of total spice and spice goods production. In India, fennel is grown on an area of 82 thousand hectares, yielding 137 thousand tonnes and an average productivity of 1.6 metric tonnes per ha. Fennel is mostly farmed in Haryana's districts of Mahendergarh, Palwal, Rewari, and Hisar, covering over 0.27 thousand hectares and yielding 0.17 metric tonnes [5].

It is evident that the productivity of fennel crops in Haryana is constrained due to increasing water crises, inadequate irrigation planning, and excessive or unbalanced usage of nutrients [6]. Inadequate irrigation planning frequently leads to low agricultural yields, which can be solved by implementing modern irrigation systems. If current irrigation techniques, like as drip irrigation, are utilized for the irrigation of fennel, both area and yield can be enhanced. Drip irrigation is superior in terms of water savings and output improvement [7]. Drip irrigation technologies, in addition to conserving water, maintain appropriate soil moisture levels, restrict wetted surfaces, avoid soil evaporation, and so have a smaller impact on the relative humidity of the microclimate [8].

Water and fertilizers are the two most important inputs in agriculture, and good management of these two resources is essential for improved yields. There are

numerous factors that influence agricultural productivity, but mineral nutrition, particularly nitrogen, is the most essential. The excessive or imbalanced use of nitrogen can dramatically reduce seed production and quality, as well as affect soil health. Nitrogen is a nutrient that plants require for growth, development, and a variety of physiological and biochemical processes. Similarly, nitrogen (N_2) fertilization is an important production component that must be considered in fennel cultivation. Fertilization is the process of providing fertilizer to crops using an irrigation system [9].

Fertigation is an important precision farming technology that can provide better fertilizer utilization efficiency than surface watering. The administration of nutrients at the wrong time and in the wrong way results in significant nutritional loss through leaching and fixation[10]. The application of fertilizer in small amounts to the soil at any given time improves fertilizer use efficiency, helps to maintain nutritional balance and nutrient concentration at an optimum level, saves energy and labor, allows the nutrient to be applied at critical stages of crop growth, and reduces the risk of groundwater contamination [11]. Fertigation is regarded as more environmentally beneficial than broadcasting because it prevents fertilizer leaching. In aromatic spices, appropriate nitrogen supply may have a direct impact on quality characteristics, volatile chemical composition, and primary yield components. However, there has been minimal research into the nutritional requirements of fennel in Haryana. The findings of this study might be useful in determining the Effect of the level of drip irrigation and nitrogen fertigation on the yield parameters of fennel.

Material Method

The present experiment entitled “Effect of irrigation and nitrogen fertigation on growth parameters of fennel (*Foeniculum vulgare* Mill)” was conducted during the *Rabi* season of 2021and 2022 at the Research Farm of the Department of Vegetable Science and in the laboratory of the Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar, Haryana. Hisar is situated between 29°10' North latitude and 75°46' East longitudes and 215.2 meters above the mean sea level. Hisar's climate is defined by semi-arid characteristics. This region is distinguished by hot, arid winds in the summer and harsh, dry weather in the winter. Before creating the experiment plan, a composite sample of soil from 0-30 cm depth was taken randomly from 10 locations in the field. The soil samples were collected, mixed, dried, and determined for mechanical and chemical analyses. According to the results of the soil analysis the soil in the experimental field had a

sandy loam texture, was non-saline, had a low organic carbon content, little available nitrogen, a high available phosphorus content, and was rich in accessible potassium.The experiment was worked out in a split-split plot design with three replications and consisted of twenty-four treatment combinations. The experiment material comprised of two fennel varieties *viz.*, HF-143 and Hisar Swarup as main plot treatment, four levels of irrigation scheduling *viz.*, I_1-0.6 IW/CPE, I_2-0.8 IW/CPE, I_3-1.0 IW/CPE and I_4-1.2 IW/CPE ratio as subplot treatments and three nitrogen levels viz., N_1-20 kg ha-1, N_2-35 kg ha^{-1} and N_3-50 kg ha^{-1} as sub-sub plot and nitrogen was applied through drip fertigation. The soil was ploughed once with a mould board plough and harrowed repeatedly to get fine tilth. The previous agricultural residues and weeds were removed from the trial area. Before ploughing the field, 8 t/ha of farmyard manure was spread over into the soil, and the experimental field was prepared by three harrowings followed by planking to make a good seed bed. The fertilizers were calculated in accordance with the treatment combinations. A half dose of nitrogen in the form of urea and a full dose of phosphorus in the form of SSP was applied as a basal dosage according to the treatments at the time of field preparation. The remaining half dose of nitrogen was delivered in three split doses 30 days after sowing using drip fertigation at about 15-day intervals at the time of the following immediate irrigation. Drip irrigation was used with cumulative pan evaporation of 0.6, 0.8, 1.0, and 1.2 IW/CPE. The total volume of water required per plot was calculated based on the area irrigated. Water is given to the crop via a network of main lines, sub-mains, and lateral lines with emission points spaced along their length in a drip system.

COLLECTION OF EXPERIMENTAL DATA

Number of umbellets/umbel

The total number of umbels emerging from ten labeled plants in each plot was counted at the time of harvesting and taken as an average.

Number of umbels/plants

The total number of umbels emerging from ten labeled plants in each plot was counted at the time of harvesting and calculated as an average.

Number of seeds/umbellet

Seeds collected from ten selected umbellets of primary umbels of labeled plants of each plot were tallied at the time of harvesting and calculated as an average.

Number of seeds/umbels

Total seeds from ten selected umbels of the labeledplants in each plot at harvesting time were tallied at the time of harvesting and calculated as an average.

Seed yield (g/plant)

All of the umbels from the five chosen plants of each treatment were harvested, dried under shade, and threshed. The average weight of cleansed seeds from five plants was recorded as seed yield per plant in grams.

Seed yield (kg/ha)

All the umbels from ten selected plants of every treatment were harvested, dried under shade, and threshed. The average weight of cleansed seeds from five plants was recorded as seed yield per plant in grams.

STATISTICAL ANALYSIS

The experimental data for different growth parameters, flowering, yield attribute features, resource usage efficiency, and seed quality were statistically analyzed using Panse and Sukhatme (1985) [12] analysis of variance (ANOVA) techniques. The critical difference (CD) for the treatment comparisons was calculated wherever the variance ratio (F test) was found significant at the 5% level of probability.

RESULT AND DISCUSSION

Yield Parameters

Results shown inTable No. 1 revealed that varieties, irrigation, and nitrogen levels significantly influenced the number of umbellets per umbel of fennel at harvest during both years. A significant maximum number of umbellets (28.36) per umbel was recorded in fennel treated with an irrigation level of 1.2 IW/CPE, which was statistically at par with fennel treated with an irrigation level of 1.0 IW/CPE (28.06), whereas, the minimum number of umbellets (26.41) per umbel was recorded in fennel treated irrigation at 0.6 IW/CPE. In similar ways, a maximum number of umbels (45.56) per plant were recorded in fennel treated with an irrigation level of 1.2 IW/CPE, which was at par with fennel treated with an irrigation level of 1.0 IW/CPE (45.41), whereas, the minimum number of umbels (39.23) per plant of fennel was recorded in fennel treated irrigation at 0.6 IW/CPE.

The next irrigation levels recorded a significantly reduced number of umbels per plant.

Results revealed that a maximum number of seeds per umbellet (21.6) were recorded in fennel supplied with an irrigation level of 1.2 IW/CPE, which was statistically at par (21.3) with fennel treated with an irrigation level of 1.0 IW/CPE during 2021-22 and 2022-23, respectively. Whereas, the minimum number of seeds per umbellet (19.5) of fennel was recorded in fennel-treated irrigation at 0.6 IW/CPE during 2021-22 and 2022-23, respectively. The maximum number of seeds per umbel (365.1) were recorded in fennel treated with an irrigation level of 1.2 IW/CPE, which was statistically at par (361.7) with fennel treated with an irrigation level of 1.0 IW/CPE, whereas, the minimum number of seeds per umbel (19.5) of fennel were recorded in fennel treated irrigation at 0.6 IW/CPE during the pooled data of both years *i.e.*, 2021-22 and 2022-23, respectively. Based on the pooled data, the number of umbellate per umbel, number of umbels per plant, number of seeds per umbellate, and number of seeds per umbel enhanced significantly by 6.8, 13.9, 9.7 and 11 percent with irrigation scheduled at 1.2 IW/CPE over 0.6 IW/CPE. This might be due to that drip irrigation ensured the availability of higher soil moisture in the root zone through the crop period. This resulted in higher irrigation relative to leaf water content, growth parameters, and dry matter production and yield of fennel. Similar results have also been reported by [2], [13], [14], [15], [16].

In the case of nitrogen levels, a significant maximum number of umbellets per umbel was recorded (27.96) in fennel treated with nitrogen at 50 kg/ha, which was statistically at par with fennel treated with nitrogen at 35 kg/ha (27.70), respectively. Whereas, the minimum number of umbellets (26.82) per umbel was recorded in fennel treated with nitrogen at 20 kg/ha. The maximum number of umbels (43.73) per plant was recorded in fennel supplied with nitrogen at 50 kg/ha. Whereas, the minimum number of umbels (42.22) per plant was recorded in fennel treated with nitrogen at 20 kg/ha during 2021-22 and 2022-23, respectively. The data pertaining to a maximum number of seeds (21.1) per umbellet were recorded in fennel treated with nitrogen at 50 kg/ha, which were statistically at par with fennel treated with nitrogen at 35 kg/ha (20.9), whereas, the minimum number of seeds (19.8) per umbellet was recorded in fennel treated with nitrogen at 20 kg/ha. The maximum number of seeds (361.3) per umbel was recorded in fennel supplied with nitrogen at 50 kg/ha, which was statistically at par with fennel treated with nitrogen

at 35 kg/ha (357). Whereas, the minimum number of seeds (329.2) per umbel was recorded in fennel treated with nitrogen at 20 kg/ha during the pooled data of 2021-22 and 2022-23, respectively. The value of yield parameters increased significantly by 4.0, 13.9, 6.2, and 8.9 percent with nitrogen levels of 50 kg/ha (N_3) over 20 kg/ha (N_1). This might be due to a healthier nutritional environment in the root zone for the growth and development of the plant as nitrogen is considered one of the major nutrients required for proper growth and development of plants and nitrogen is the main constituent of protoplasm, cell nucleus, amino acids, chlorophyll and many other metabolic processes. The present findings are in close agreement with the results obtained by [16], [15], [14],[2].

Table:1Effect of irrigation levels and nitrogen fertigation on yield attributes of two different fennel varieties

Treatments	Number of umbellet per umbel	Number of umbel per plant	Number of seed per umbellet	Number of seed per umbel
Varieties				
V1: Hisar Swarup	23.14	38.62	19.7	303.9
V2: HF- 143	31.85	47.72	21.5	394.4
C.D. at 5%	0.77	0.95	0.5	6.8
Irrigation scheduling				
I1: Irrigation at 0.6 IW/CPE	26.41	39.23	19.5	324.7
I2: Irrigation at 0.8 IW/CPE	27.14	42.49	20.0	345.1
I3: Irrigation at 1.0 IW/CPE	28.06	45.41	21.3	361.7
I4: Irrigation at 1.2 IW/CPE	28.36	45.56	21.6	365.1
C.D. at 5%	0.50	0.22	0.3	5.1
Nitrogen levels				
N1: Nitrogen at 20 kg/ha	26.82	42.22	19.8	329.2

N2:Nitrogen at 35 kg/ha	27.70	43.57	20.9	357.0
N3: Nitrogen at 50 kg/ha	27.96	43.73	21.1	361.3
C.D. at 5%	0.30	0.14	0.2	4.1

Irrigation levels :- I_1: 0.6 IW/CPE, I_2: 0.8 IW/CPE, I_3: 1.0 IW/CPE and I_4: 1.2 IW/CPE through drip

Nitrogen levels:- N_1: @20 kg/ha, N_2: @35 kg/ha and N_3: @50 kg/ha

Among varieties, the significant maximum number of umbellets (31.85) per umbel, number of umbels (47.72), number of seeds per umbellet (21.5), and number of seeds (394.4) per umbel of fennel was recorded in HF-143 and the minimum was recorded with Hisar Swarup. The numbers of umbellate per umbel, the number of umbels per plant, the number of seeds per umbellate, and the number of seeds per umbel were significantly increased by 27.3, 19.1, 8.4, and 22.9 percent in HF-143 over Hisar Swarup, respectively. The yield attributes of fennel crops were increased significantly by irrigation scheduling and nitrogen levels with respect to different cultivars. These results are similar in accordance to [17].

Seed yield (g/plant and kg/ plant)

The data relevant to seed yield (Table 2) showed that varieties, irrigation, and nitrogen levels significantly influenced the seed yield of fennel during both years. Among irrigation levels, a significantly higher yield (17.4g/plant and 1834.0 kg/ha) was recorded in fennel-treated irrigation at 1.2 IW/CPE, which was statistically at par with fennel treated with irrigation level at 1.0 IW/CPE (17.3g/plant and 1824.4kg/ha), while minimum yield was obtained when fennel treated with irrigation level at 0.6 IW/CPE (11.8g/plant and 1246.7 kg/ha). The seed yield per plant and hectare were significantly increased by 32.2 and 32.1 percent through irrigation scheduling at 1.2 IW/CPE over 0.6 IW/CPE when analyzed for two years. The crop's seed yield is the consequence of various physiological processes that occur while the crop is growing. The optimal moisture state in the crop's complete root zone manifests in improved physiological activities of plant plants. The use of an optimum amount of irrigation water maintained proper soil moisture when overcoming moisture stress during the growth season, resulting in

increased yield. The current study's findings were quite similar to those of [18], [14], [15].

The effect of different nitrogen levels resulted in significantly higher seed yield (15.5g/plant and 1640.8kg/ha)which was recorded maximum in nitrogen at 50 kg/ha, whereas, the lowest seed yield (15.0g/plant and 1580.2kg/plant) was recorded in fennel treated with nitrogen at 20 kg/ha during 2021-22 and 2022-23, respectively. Similarly, while comparing the effect of nitrogen levels the seed yield per plant and hectare significantly increased by 3.2 and 3.6 percent at 50 kg/ha over 20 kg/ha. This may be due to the appropriate and sufficient fertilizer application through drip fertigation made it possible to the crop nutrient requirement at various growth stages resulting in improved growth and yield. Water-soluble nitrogen fertilizer can be applied via fertigation through the drip system. Similar results were obtained by [14], [21],

Among different varieties, a significantly higher seed yield of fennel (16.5g/plant and 1,741.2 kg/ha) was recorded in HF-143 over Hisar Swarup. Seed yield per hectare was significantly increased by 14.9 percent in HF-143 over Hisar Swarup. This is one to the fact that variety HF-143 had bolder seeds as compared to other varieties.

Table: 3Effect of irrigation levels and nitrogen fertigation on seed yield (g/plant) and seed yield (kg/hectare) of two different fennel varieties

Treatments	Seed yield (gram/plant)			Seed yield (kg/hectare)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Varieties						
V1: Hisar Swarup	14.2	13.9	14.0	1,500.8	1,463.9	1,482.4
V2: HF- 143	16.5	16.5	16.5	1,738.6	1,743.8	1,741.2
C.D. at 5%	0.3	0.5	0.2	28.2	51.3	25.4
Irrigation scheduling						
I1: Irrigation at 0.6 IW/CPE	12.0	11.6	11.8	1264.4	1,228.9	1,246.7
I2: Irrigation at 0.8 IW/CPE	14.7	14.5	14.6	1557.9	1,526.4	1,542.2
I3: Irrigation at 1.0 IW/CPE	17.3	17.3	17.3	1824.7	1,824.0	1,824.4
I4: Irrigation at 1.2 IW/CPE	17.3	17.4	17.4	1831.8	1,836.2	1,834.0
C.D. at 5%	0.2	0.2	0.2	17.7	24.9	15.3

Nitrogen levels						
N1: Nitrogen at 20 kg/ha	15.0	14.9	15.0	1589.0	1,571.4	1,580.2
N2:Nitrogen at 35 kg/ha	15.4	15.2	15.3	1624.0	1,604.7	1,614.4
N3: Nitrogen at 50 kg/ha	15.6	15.5	15.5	1646.1	1,635.5	1,640.8
C.D. at 5%	0.1	0.1	0.1	11.1	11.1	6.7

Irrigation levels :- I_1: 0.6 IW/CPE, I_2: 0.8 IW/CPE, I_3: 1.0 IW/CPE and I_4: 1.2 IW/CPE through drip

Nitrogen levels:- N_1: @20 kg/ha, N_2: @35 kg/ha and N_3: @50 kg/ha

Interaction effect of irrigation and nitrogen levels (I×N) revealed that (Table 3) significantly higher seed yield (1,854.65kg/ha) was recorded in fennel sown at irrigation level of 1.2 IW/CPE with nitrogen applied at 50 kg/ha (I_4N_3), which was statistically at par with fennel sown at irrigation level of 1.0 IW/CPE with nitrogen applied at 50 kg/ha (1,848.99kg/ha), whereas, the lowest seed yield (1185.66 kg/ha) was recorded in fennel sown at irrigation level of 0.6 IW/CPE with nitrogen applied at 40 kg/ha. The interaction effect of varieties, fertilizer, and irrigation levels (V×I×N) revealed that significantly higher seed yield of fennel was recorded in fennel sown at an irrigation level of 1.2 IW/CPE with nitrogen at 50 kg/ha in each variety. Significantly higher seed yield (1,985.18kg/ha) was recorded in variety HF-143 sown at an irrigation level of 1.2 IW/CPE with nitrogen at 50 kg/ha ($V_2I_4N_3$), which was statistically at par with fennel sown at irrigation level of 1.0 IW/CPE with nitrogen at 50 kg/ha (1,978.48kg/ha). Whereas, the lowest seed yield (1,013.50kg/ha) of fennel was recorded in the fennel variety Hisar Swarup sown at an irrigation level of 0.6 IW/CPE with nitrogen at 20 kg/ha ($V_1I_1N_1$).

Table: 3 Effect of irrigation levels and nitrogen fertigation on seed yield (kg/hectare) of two different fennel varieties

Nitrogen levels	Variety × Irrigation × Nitrogen								
	Varieties								
	V_1 : Hisar Swarup				V_2 : HF- 143				
	Irrigation levels								
	I_1	I_2	I_3	I_4		I_1	I_2	I_3	I_4
N_1	1,013.50	1,408.74	1,676.46	1,692.04	N_1	1,357.81	1,628.42	1,933.83	1,930.85
N_2	1,133.50	1,424.73	1,682.33	1,707.69	N_2	1,384.77	1,662.31	1,955.53	1,963.94
N_3	1,172.23	1,433.39	1,719.49	1,724.12	N_3	1,418.11	1,695.39	1,978.48	1,985.18

Varieties	Variety × Irrigation					Varieties	Variety × Nitrogen			
	Irrigation levels						Nitrogen levels			
	I_1	I_2	I_3	I_4	Mean V		N_1	N_2	N_3	Mean V
V_1	1,106.41	1,422.29	1,692.76	1,707.95	1,482.35	V_1	1,447.68	1,487.06	1,512.31	1482.35
V_2	1,386.90	1,662.04	1,955.95	1,959.99	1,741.22	V_2	1,712.73	1,741.64	1,769.29	1,741.22
Mean I	1,246.65	1,542.16	1,824.36	1,833.97		Mean N	1,580.21	1,614.35	1,640.80	

Irrigation levels	Irrigation × Nitrogen					CD at 5% level of significance	
	Nitrogen levels					Variety	25.44
	N_1	N_2	N_3	Mean I		Irrigation	15.32
I_1	1,185.66	1,259.13	1,295.17	1,246.65		Nitrogen	6.75
I_2	1,518.58	1,543.52	1,564.39	1,542.16		Variety × Irrigation	NS

I_3	1,805.15	1,818.93	1,848.99	1,824.36		Variety × Nitrogen	NS
I_4	1,811.44	1,835.82	1,854.65	1,833.97		Irrigation × Nitrogen	13.48
Mean N	1,580.21	1,614.35	1,640.80			Variety × Irrigation × Nitrogen	19.03

Irrigation levels :- I1: 0.6 IW/CPE, I2: 0.8 IW/CPE, I3: 1.0 IW/CPE and I4: 1.2 IW/CPE through drip

Nitrogen levels:- N1: @20 kg/ha, N2: @35 kg/ha and N3: @50 kg/ha

While comparing the interaction effect of different irrigation scheduling with nitrogen levels, seed yield kg/hectare significantly increased by 49.0 percent at irrigation scheduling 1.2 IW/CPE with 50 kg/ha of nitrogen level over-irrigation scheduling at 0.6 IW/CPE with 20 kg/ha nitrogen level. Biological yield significantly increased by 35.2 percent in fennel sown at irrigation scheduling of 1.2 IW/CPE with 50 kg/ha of nitrogen level over-irrigation scheduling at 0.6 IW/CPE with 20 kg/ha nitrogen level. The increase in yield might be due to better water utilization and uptake of nutrients and excellent soil-water relationship in the root zone. Similar results were obtained by [22], [23], [24], [25].

4. CONCLUSION

Based on the results of two year's experiments, it is recommended that fennel varietyHF-143 was found superior as compared to Hisar Swarup in respect of quality parameters to get higher seed yield when grown at irrigation scheduling at 1.0 IW/CPE and nitrogen at 50 kg/ha western region of Haryana.

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