Effect of drip irrigation and nitrogen fertigation on some growth parameters of fennel

ABSTRACT

The present investigation titled "Effect of drip irrigation and nitrogen fertigation on growth parameters of fennel" was conducted during the *Rabi* season for two years 2021-22 and 2022-23 at Research Farm of the Department of Vegetable Science, ChaudharyCharanSingh Haryana Agricultural University, Hisar, Haryana.The experiment consists of two varieties *viz*.,V_1: HisarSwarup, V_2: HF 143, four Irrigation scheduling*viz*.,I_1: 0.6 IW/CPE (Irrigation water/ Cumulative pan evapotranspiration) through drip, I_2: 0.8 IW/CPE through drip, I_3: 1.0 IW/CPE through drip, I_4: 1.2 IW/CPEthrough drip, three nitrogen levels *viz*., N_1: 20 kg/ha, N_2: 35 kg/ha, N_3: 50 kg/ha. During field preparation, half a dose of nitrogen as urea and a full dose of phosphorus in the form of SSP were applied as a basal dosage. Necessary measurements and plant protection measures were implemented following the recommended package practice of HAU to manage insectpests and diseases. There is a increase in growth parameters *viz*., plant height , number of primary and secondary branches, days to 50% maturity and flowering when drip irrigation and nitrogen levels increases.The study concluded that variety HF-143 with irrigation scheduling I_3 and nitrogen dose N_3 were found superior over other treatments for better growth parameters.

Keywords: Drip irrigation, nitrogen fertigation, growth parameters, IW/CPE, Fennel.

INTRODUCTION

"Fennel (*Foeniculumvulgare* Mill) is a plant belonging to the family Umbelliferae (Apiaceae). It is generally considered indigenous to the shores of the Mediterranean but has become widely naturalized in many parts of the world, especially on dry soils near the sea coast and on riverbanks. Fennel a seed spices crop well known for its aromatic and medicinal properties and it has been used by humans since antiquity. It is a hardy, perennial herb with yellow flowers and feathery leaves soft, almost hair-like foliage growing upto 2 m (6.6 feet) tall" [1]. "The flowers are bright yellow in color, small in size, and found in large flat-topped umbels. Fruits are oblong to ovoid 3–5 mm long and 1.5–2.0 mm broad. All parts

of this plant are aromatic and can be used in numerous ways. Ripen edible fruits or seeds of fennel crop are sweet and dry, this dried fruit is called fennel which is a major part of commerce"[2].

"The fruits (seeds) are used as stimulants, carminative, and in cure of colic pain. The volatile compounds aroma in fennel makes it an excellent flavoring agent such as estragole, fenchone, and trans-anethole have appeared as major phytoconstituents of fennel species. As per USDA data, it has the highest plant sources of sodium, potassium, calcium, and phosphorus. Fennels are also rich in vitamins,and dietary fibre and have smaller amounts of many other nutrients in respect to human needs"[3].

India is a major seed spices producer in the world because of its favorable climatic and soil conditions for growing spices and other tropical herbs therefore it is known asthe "Home of Spices". "The major seed spices growing area is concentrated in semi-arid to arid areas of Gujarat and Rajasthan, together contributing more than 80% of the total seed spices produced in the country. Therefore both the states are esteemed as "Seed Spice Bowl of India". Out of 20 seed spices crops Cumin, Coriander, Fennel, Fenugreek, dill, and ajowain contributed more than 95% towards area and production. Among seed spices fennel contributes to about 17.4% of the total seed spice production"[4].

"Despite this fact, the productivity of the fennel crop in Haryana is just half of its potential productivity. The reasons for low productivity may be attributed to poor management practices particularly irrigation and nutrient management. Poor irrigation planning often leads to low crop yields. In such areas having plenty and cheap water resources with secured supplies during the crop season, makes it possible to apply water as and when required to assemble the full water required of crops and realize the highest yields. On the other hand, in recent years water resources have become scarce due to an increase in cultivated areas and poor renewal of groundwater especially in arid and semi-arid"[5]."Drip irrigation can be an important tool in increasing fennel yield substantially by maintaining moisture content in soil at near field capacity on one hand and by eliminating water losses on the other hand. Thus, the adoption of drip irrigation in fennel can save a huge amount of irrigation water which can be used for horizontal increase of irrigation areas. Evapotranspiration-based scheduling of irrigation is a proper and scientific to provide required irrigation water through a drip system for harnessing the potential yield of fennel crops"[6].

The two most significant inputs in agriculture are water and nutrients, and the effective management of these two resources is crucial for higher yields. Many factors affect crop productivity, but mineral nutrition, particularly nitrogen, is the most important one. The

growth parameters and quality of seeds can be significantly decreased, and soil health can be greatly compromised by the excessive or unbalanced usage of nitrogen. “Nitrogen is an essential plant nutrient for growth, development, and various physiological and biochemical processes. Similarly in fennel cultivation, a major production factor that must be considered is nitrogen (N2) fertilization”[7].

The process of applying fertilizer to crops through an irrigation system is known as "fertigation." The right amount of irrigation and fertilizer application not only enhances yield but also enhances quality while lowering production costs, which is exactly what needs to be done today [8]. “Fertigation is one important precision farming technique that can give better nutrient use efficiency as compared to surface irrigation methods. Application of nutrients untimely and following inappropriate methods of application leads to severe loss of nutrients by leaching and fixation”[9].“Application of fertilizer in small quantities 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, provides an opportunity to apply the nutrient at critical stages of crop growth and minimizes hazard of groundwater”[10].

Fertigation is considered eco-friendly compared to broadcasting as it avoids the leaching of nutrients. In aromatic spices, the adequate nitrogen supply may have a direct effect on the quality aspects, the composition of volatile compounds, and their primary yield components. However, very little attention has been given to studying the nutritional requirements of fennel in Haryana.

The results of this study will aid in applying fertilizer to the fennel crop appropriately using drip irrigation and in optimizing the cost of technology inputs in accordance with local soil, climatic, and crop circumstances.The present study was undertaken to find out the “Effect of drip irrigation and nitrogen fertigation on growth parameters of Fennel”.

2. MATERIAL METHOD

2.1 EXPERIMENTAL DESIGN

The present experiment entitled “Effect of irrigation and nitrogen fertigation on growth parameters of fennel (*Foeniculumvulgare*Mill)” was conducted during the *Rabi* season of 2021and 2022 at 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, India. Hisar is situated between 29°10' North latitude and 75°46' East longitudes and 215.2 meters above mean sea level. Hisar has a climate characterized by

semi-arid conditions. This region is characterized by hot, arid winds during the summer and severe, dry weather during the winter. The field used for the experiment had been uniformly prepared. According to the soil analysis data, the soil in the experimental field was sandy loam in texture, non-saline, low in organic carbon, low in available nitrogen, high in available phosphorus, and rich in accessible potassium.The experiment was laid 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 HisarSwarup 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.

2.2 CULTURAL PRACTICES

Following the harvest of the previous crop, the soil was ploughed once with a mould board plough and harrowed repeatedly to get fine tilth. 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 land was leveled and split into plots of 3 m × 1.35 m. Finally, the raised beds with 1.2 m width were set out by creating tiny waterways between the plots.The fertilizers were calculated in accordance with the treatment combinations. Pre-sowing irrigation (40 mm) was used prior to field preparation to improve seed germination. The crop was irrigated and fertilized using a drip irrigation method. 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. Seed sowing took place on October 20th and 31st, 2021-22 and 2022-23, respectively. Plant protection measures were also implemented in accordance with the recommended package practice of Haryana Agricultural University to manage insectpests and diseases.

2.3 COLLECTION OF EXPERIMENTAL DATA

2.3.1 Plant height (cm)

The plant height was taken from ten randomly selected plants from each plot at 45, 60, and 90 days and harvesting in centimeters from the bottom of the plant up to the tip of the main stem, and the average of these plants was calculated and given as the centimeter plant height.

2.3.2 Number of primary branches/plants

The branches that had emerged from the main shoots from the ten previouslytagged plants from each plot were taken into account and averaged at 45, 60, and 90 days and harvesting.

2.3.3 Number of secondary branches/plants

The total number of branches that emerged from the primary branches was counted from ten labeled plants at 45, 60, and 90 days after sowing and at harvest and averaged.

2.3.4 Days to 50% flowering

The number of days from the date of sowing to the day when 50% of plants in a plot in each replication showed flowering were taken into account and averaged.

2.3.5 Days to 50% maturity

The number of days from the date of sowing to the day when 50% of plants in a plot in each replication showed maturity were taken into account and averaged.

2.4 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) [11] 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.

3. RESULT AND DISCUSSION

3.1 Plant height

Plant heightson different days such as 45, 60, 90, and at harvest were shown in Table 1. Among irrigation levels, significantly higher plant height was recorded in fennel-treated irrigation at 1.2 IW/CPE (20.65 cm, 39.07 cm, 98.92 cm, and 135.64 cm) and lowest at 0.6 IW/CPE. It has also been evidenced that there were 22, 17, 25, and 17 percent increased plant height on account of higher irrigation *i.e.* 1.2 IW/CPE over 0.6 IW/CPE during 45, 60, and 90 DAS and at harvest, respectively.

The increase in plant height by irrigation might be attributed to the beneficial effect of higher soil moisture status on the absorption of water, uptake of nutrients, cell turgidity, cell elongation, net-assimilation rate, and translocation of assimilates to the actively growing parts of the plant. Similar results were also reported by [12,13,14,15,16].

The nitrogen levels resulted in 5, 5, 4, and 3 percent taller plants at nitrogen levels of 50 kg/ha over 20 kg/ha during 45, 60, and 90 DAS and at harvest (19.33, 37.32, 93.19, and

129.86 cm), respectively. The increment in plant height by additional application of nitrogen might be due to the favourable function of nitrogen. Nitrogen, being a primary structural element of cells, stimulates cell division and elongation, resulting in improved vegetative development. This finding is supported by the results reported by [17,18, 19, 20, 21, 22, 23,24]. When plant height was analyzed for different varieties of fennel, significantly 5, 5, 4, and 3 percent taller plants were found from HF-143 over HisarSwarup at 45, 60, 90 DAS and harvest (19.36, 37.06, 93.98, and 134.45 cm), respectively. The increase in plant height might be attributed to the genetic characteristics of various varieties which is also similar to the findings of [25,16].

Table: 1 Effect of irrigation levels and nitrogen fertigation on plant height (cm) at 45, 60, 90 DAS and at harvest of different fennel varieties

Treatments	Plant height (cm)			
	45 Days After Sowing	60 Days After Sowing	90 Days After Sowing	At Harvest
Varieties				
V_1: HisarSwarup	18.29	35.57	89.43	121.56
V_2: HF- 143	19.36	37.06	93.98	134.45
L.C.D. at 5%	0.27	0.36	0.57	0.32
Irrigation scheduling				
I_1: Irrigation at 0.6 IW/CPE	16.79	33.31	78.56	115.82
I_2: Irrigation at 0.8 IW/CPE	17.61	34.84	91.41	126.61
I_3: Irrigation at 1.0 IW/CPE	20.24	38.04	97.94	133.94
I_4: Irrigation at 1.2 IW/CPE	20.65	39.07	98.92	135.64
L.C.D. at 5%	0.16	0.40	0.28	0.26
Nitrogen levels				
N_1: Nitrogen at 20 kg/ha	18.34	35.45	89.24	125.43
N_2:Nitrogen at 35 kg/ha	18.80	36.18	92.69	128.72
N_3: Nitrogen at 50 kg/ha	19.33	37.32	93.19	129.86
L.C.D. at 5%	0.18	0.35	0.21	0.26

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

3.2 NUMBER OF PRIMARY AND SECONDARY BRANCHES AT HARVEST

Results showed in Table no. 2 revealed that varieties, irrigation, and nitrogen levels significantly influenced the numbers of primary and secondary branches per plant of fennel at harvest during both years. The maximum number of primary branches per plant (9.76) was recorded in fennel-treated irrigation at 1.2 IW/CPE, which was statistically at par with the

irrigation level at 1.0 IW/CPE (9.70) and minimum at 0.6 IW/CPE (8.42). Following the same trend significant maximum number of secondary branches (19.07) per plant was recorded in fennel-treated irrigation at 1.2 IW/CPE which was at par with (18.73) irrigation level at 1.0 IW/CPE, whereas, the minimum numbers of secondary branches (18.06) per plant was recorded in fennel treated irrigation at 0.6 IW/CPE respectively.

The data relating to the effect of nitrogen level showed maximum number of primary branches (9.29) per plant was recorded in fennel-treated nitrogen at 50 kg/ha, which was statistically at par (9.23) with nitrogen at 35 kg/ha, whereas the minimum branches (9.07) were recorded with lowest nitrogen level (20 kg/ha). Several secondary branches per plant over two years also followed the same trend and a significantly maximum number of secondary branches (18.72) per plant were recorded in fennel-treated nitrogen at 50 kg/ha, which was statistically at par (18.59) with nitrogen at 35 kg/ha.

Among varieties, a significant maximum number of primary branches per plant (10.51) and a number of secondary branches per plant (19.66) at harvest was recorded in HF-143, over HisarSwarup.

Based on the data of two years, the number of primary branches significantly increased by 1.9 percent at harvest of fennel, similarly, secondary branches per plant significantly increased by 5.2 percent during harvest when irrigation scheduling at 1.2 IW/CPE (I_4) was used over 0.6 IW/CPE (I_1), respectively and closely followed by irrigation scheduled at 1.0 IW/CPE ratio (I_3). The increased number of branches per plant might be attributed to the availability of sufficient soil moisture for progressive plant growth, which is maintained by drip irrigation, resulting in higher development of photosynthetic area and faster photosynthetic rate. Similar findings were reported by [12,13,20, 25,29].

Among nitrogen levels number of primary branches per plant significantly increased by 2.3 percent and secondary branches by 2.2 percent at harvest with nitrogen level at 50 kg/ha (N_3) over 20 kg/ha (N_1). This might be due to higher levels of nitrogen, which may have boosted interception, absorption, and utilization of radiant energy, leading to increased photosynthesis and, as a result, the number of branches per plant, resulting in better development. A similar findings were reported by [26, 21].

The increase in the number of primary and secondary branches per plant might be attributed to genetic differences across varieties. The number of primary branches per plant significantly increased by 25 percent in variety HF-143 at harvest over HisarSwarup.The number of secondary branches also increased by 11.4 percent at harvest HisarSwarup. Similar findings were reported by [27].

Table 2. Effect of irrigation levels and nitrogen fertigation on the number of primary branches, number of secondary branches, days to 50% flowering, and days to 50% maturity of different fennel varieties

Treatments	Primary Branches	Secondary Branches	50% Flowering	50% Maturity
Varieties				
V_1: HisarSwarup	7.88	17.41	99.4	119.9
V_2: HF- 143	10.51	19.66	102.0	128.4
L.C.D. at 5%	0.15	0.32	0.21	1.26
Irrigation scheduling				
I_1: Irrigation at 0.6 IW/CPE	8.42	18.06	98.1	118.8
I_2: Irrigation at 0.8 IW/CPE	8.90	18.29	99.5	121.9
I_3: Irrigation at 1.0 IW/CPE	9.70	18.73	101.6	126.0
I_4: Irrigation at 1.2 IW/CPE	9.76	19.07	103.6	130.1
L.C.D. at 5%	0.08	0.34	1.22	2.29
Nitrogen levels				
N_1: Nitrogen at 20 kg/ha	9.07	18.30	99.7	122.4
N_2:Nitrogen at 35 kg/ha	9.23	18.59	100.8	124.2
N_3: Nitrogen at 50 kg/ha	9.29	18.72	101.6	126.0
L.C.D. at 5%	0.07	0.21	1.04	1.47

3.3 Days to 50% flowering and days to 50% maturity

The data pertaining to days to 50% flowering and days to 50% maturity are presented in Table 2. The data clearly showed that varieties, irrigation, and nitrogen levels

significantly influenced the days to 50% flowering of fennel. Among irrigation levels, significant minimum days were taken to 50% flowering (98.1) when fennel irrigated with the lowest level of irrigation *i.e.* 0.6 IW/CPE, while more number days were taken to 50% flowering in fennel applied irrigation at 1.2 IW/CPE (103.6). In different nitrogen levels, the significant minimum number of days taken to 50% flowering (99.7) was recorded when fennel treated with nitrogen at 20 kg/ha, whereas, the maximum number of days were taken to 50% flowering (101.6) was recorded in fennel treated nitrogen at 50 kg/ha. Among varieties, meaningfully minimum number of days was taken to 50% flowering with HisarSwarup (99.4) over HF-143 (102.0).

The data on irrigation levels indicated that significantly minimum numbers of days were taken to maturity (118.8) when fennel irrigated at 0.6 IW/CPE, however,agreater number of days taken to maturity (130.1) were recorded in fennel treated irrigation at 1.2 IW/CPE. In the case of nitrogen levels, the significantly minimum number of days were taken to maturity (122.4) with 20 kg/ha, while the greater number of days taken to maturity (126.0) was recorded in fennel-treated nitrogen at 50 kg/ha. Among different varieties, the significantly minimum number of days taken to maturity (119.9) was observed with HisarSwarup of fennel in over HF-143 (128.4).

This might be due to the fact that irrigation scheduled at 0.6 IW/CPE resulted in vegetative growth and carbohydrate accumulation which influenced early flowering-assisted bioavailability of sunlight and optimum availability of water. Similar results were obtained by [13,20].

The lower nitrogen dose could not carry out the nutritional requirement of plant for better root growth and vegetative growth, which ultimately resulted in reduced growth, early accumulation of photosynthates and ultimately early flowering and fruiting. While, optimum nitrogen dose maintained the appropriate nutritional environment in the root zone, which balanced the physiological process and could helps in proper utilization and uptake of nutrients resulted in better vegetative growth and delayed the flowering and fruiting. Further it helped in proper development of seed by maintaining source and sinks relationship and finally resulted in early and prolonged harvesting. Similar results were obtained by [13,20].

Among the different varieties, this variance may be attributed to the genetic characteristics of various fennel cultivars. Similar findings were reported by [27].

4. CONCLUSION

From the present study, it has been concluded that in the areas of less water availability or to reduce irrigated water requirement for fennel crop variety HF-143 with irrigation scheduling I_3 and nitrogen dose N_3 were found superior over other treatments for better growth parameters of fennel crop in the region of Haryana for drip irrigation and nitrogen fertigation.

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