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Amaratpal Singh
 M.Sc. Research Scholar,
 Department of Horticulture,
 College of Agriculture,
 Bikaner, Rajasthan, India

RK Narolia
 Assistant Professor,
 Department of Horticulture,
 College of Agriculture,
 Bikaner, Rajasthan, India

PK Yadav
 Professor and Head,
 Department of Horticulture,
 College of Agriculture,
 Bikaner, Rajasthan, India

Naresh Kumar
 M.Sc. Research Scholar,
 Department of Horticulture,
 College of Agriculture,
 Bikaner, Rajasthan, India

Atma Ram Meena
 Ph.D. Research Scholar,
 Department of Horticulture,
 College of Agriculture,
 Bikaner, Rajasthan, India

Ramandeep Kour
 Ph.D. Research Scholar,
 Department of Horticulture,
 College of Agriculture,
 Bikaner, Rajasthan, India

Corresponding Author:
Amaratpal Singh
 M.Sc. Research Scholar,
 Department of Horticulture,
 College of Agriculture,
 Bikaner, Rajasthan, India

Response of Fennel (*Foeniculum vulgare* Mill.) cultivars on yield and economics attributes with different irrigation levels under drip system

Amaratpal Singh, RK Narolia, PK Yadav, Naresh Kumar, Atma Ram Meena and Ramandeep Kour

Abstract

This experiment was laid out with split plot design with three replications. The treatments comprised of four Pan Evaporation levels (0.55, 0.70, 0.85 and 1.0 PE) assigned to main plots and four cultivars of fennel crop (RF-101, RF-125, RF-143, and RF-205) assigned to sub plots. The experiment results revealed that yield and economics attributes were significantly increased by increasing irrigation levels and influenced by different fennel cultivars. Irrigation level 1.0 PE maximum number of seeds umbel⁻¹ (221.57), seed yield (2304 kg ha⁻¹) and stover yield (4263 kg ha⁻¹), harvest index (35.09 percent), Net return (1,29,002 ₹ha⁻¹) and B:C ratio (4.16) was recorded, which was at par with 0.85 PE. Cultivar RF-205 was recorded maximum number of seeds umbel⁻¹ (209.48) seed yield (2069 kg ha⁻¹), stover yield (4126 kg ha⁻¹), Net returns (114670 ₹ha⁻¹) and B: C ratio (3.96). Harvest index of fennel did not influenced due to various cultivars of fennel.

Keywords: Fennel, pan evaporation, cultivar, yield, economics

Introduction

The Fennel (*Foeniculum vulgare* Mill.) is an important seed spice in India mainly grown in rabi season. Fennel belongs to family Apiaceae. *Foeniculum* is diploid having 2n=22 chromosomes. It is a native of Southern Europe and Mediterranean. Later it spread to the far East and North in Europe. Most of the production of fennel seed spices is coming from semi-arid and arid parts of Rajasthan states known as the "bowl of seed spices" in Rajasthan; it occupies an area of 26.2 thousand hectare with production of 25.6 thousand tonnes and productivity of 10.52 q ha⁻¹ (DOR, 2019-20). About 33% of total production is being contributed by Rajasthan in India. The major fennel producing districts of Rajasthan are Nagaur, Sirohi, Jalore, Dausa, Tonk, Sawai Madhopur and occupy above 90 per cent of area and production of fennel crop.

India is also called the world over as 'The Home of Spices', thus Spices and condiments need no introduction. The temperature of the country is ideal for the growth of almost all spices. Spices are an important group of agricultural goods, which are virtually indispensable in the culinary art. They also play a significant role in our Indian economy and also in the economies of several spice producing, exporting and importing countries. India accounts for about 45% of the global spice exports. In India, from the point of view of both domestic consumption and export, spices are important commercial crops.

According to the International Organization for Standardization [ISO], there are about 109 spices and India produces as many as 75 in its various agro climatic regions. The term "spices and condiments" applies to natural plant or vegetable products or mixtures in whole or ground form, which are used for imparting flavor, aroma and piquancy to the food items. Spices are also being used within the country for flavoring foods and in medicines, pharmaceutical, perfumery, cosmetics and several other industries.

The PE approach allows the preparation of irrigation time table for different crops. PE based scheduling of irrigation is a proper approach for applying irrigation water through drip system for optimum yield potential of fennel crop as it includes all the environmental parameters.

Material method

The field experiment was conducted at Instructional Farm, College of Agriculture, S.K. Rajasthan Agricultural University, Bikaner (Raj.). Bikaner is situated at 28° 01'N latitude and 73° 22'E longitude at an altitude of 234.70 meters above Mean Sea Level. According to "Agro-ecological region map" brought out by the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Bikaner falls under Agro-ecological region No. 2 (MgE1) under arid ecosystem (Hot Arid Eco-region with desert and Saline soil), which is characterized by deep, sandy and coarse loamy, desert soils with low water holding capacity, hot and arid climate. As per NARP, Bikaner falls in Agro climatic zone Ic (Hyper Arid Partially Irrigated North Western Plain Zone). According to National Planning Commission, Bikaner falls under Agro-climatic zone XIV (Western Dry Region) of India. The periodical mean weekly weather parameters recorded for the period of the experimentation. The maximum temperature ranged between 18.3°C and 39.5°C during the crop growing season in the 2th and 15th standard meteorological weeks, respectively. Likewise, the values of minimum temperature i.e., 2.3°C and 22°C was recorded in the 52th and 15th standard meteorological weeks, respectively. Crop received 75.4 mm of rainfall with 10 rainy days in the growing season. Evaporation ranged from 4.0 to 11.1 mm day⁻¹ during the crop growing period. The analytical results revealed that the soil of the experimental field was loamy sand in texture and slightly alkaline in reaction (pH 8.5), poor in organic carbon (0.12 per cent), low in available nitrogen (117 kg ha⁻¹) but medium in available phosphorus (15.4 kg ha⁻¹) and potassium (172.7 kg ha⁻¹).

The experiment was laid out in split plot design four different irrigation levels 1.0 PE, 0.85 PE, 0.70 PE and 0.55 PE through drip system in main plot and four different cultivars RF- 101, RF- 125, RF-143 and RF-205 in sub main plot and three replication. The pure, healthy, disease and insect free vigorous and good quality seeds of fennel cultivars RF 101, RF 125, RF 143 and RF 205 were used for sowing. The seeds of fennel were sown on 24th October 2019. Sowing was done by khera method and seed rate 10 kg ha⁻¹ at the depth of 2-3 cm. Recommended dose of N and P₂O₅ i.e. 90:40 Kg per ha was applied through urea and DAP, respectively. The whole amount of P and 30 kg N were applied as basal dressing prior to sowing. While remaining nitrogen was top dressed in two equal splits doses (45 DAS and at flowering).

Under drip system immediately after sowing 25 mm water was applied to ensure proper germination, thereafter, irrigation was applied at alternate days as per treatments. The applied irrigation water was calculated by evaporation data of daily basis. Therefore, dripper discharge rate per hour and one dripper cover area per plot were calculated for applying irrigation water and then calculated the amount of water (1mm) was applied in the field to operate drip system per hour. This calculated time was multiplied with evaporation data and converted according to PE levels viz., 0.55, 0.70, 0.85 and 1.0. In the experiment observation was taken following methods.

Number of seeds per umbel at the time of threshing, 10 umbels were randomly selected from tagged plants in each plot and their total seeds were counted to record average number of seeds per umbel.

After threshing, winnowing and cleaning, the produce of each net plot were weighed and the weight was recorded in g plot⁻¹ and then converted in to kg ha⁻¹ by using following formula-

$$\text{Seed yield (Kg ha}^{-1}\text{)} = \frac{\text{Seed yield (g) / plot (sq m)} \times 10000}{\text{Size of plot (sq m)} \times 1000}$$

After final plucking of umbels, plants from net plot area were cut out at the base, tied in bundles and left for sun drying. After complete drying bundle were weighed to record Stover yield. Thus was presented as kg ha⁻¹.

Harvest index (HI) was computed as the ratio of economic yield i.e. seed yield to the total biomass i.e. biological yield (seed + Stover) from same area and expressed in percentage. The harvest index was worked out as per formula advocated by Singh and Stoskoff (1971)

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

The cost of cultivation for each treatment was subtracted from gross returns worked out for the respective treatment to arrive at net returns for each treatment

Net returns (₹ha⁻¹) = Gross returns (₹ha⁻¹) – Cost of cultivation (₹ha⁻¹)

Treatment wise benefit: cost ratio was calculated to ascertain economic viability of the treatment using the following formula:

$$\text{B : C ratio} = \frac{\text{Gross returns (₹ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ha}^{-1}\text{)}}$$

Result and discussion

Number of seeds umbel-1

Data presented in Table 1 revealed that number of seeds umbel⁻¹ in fennel were significantly influenced due to irrigation levels. Irrigation with 1.0 PE recorded maximum number of seeds umbel⁻¹ (221.57) as compared to 0.55 PE and 0.70 PE but statistically at par with 0.85 PE levels of irrigation. Highest number of seeds umbel⁻¹ (209.48) was recorded in RF-205 as compared to RF - 101, RF -125 and RF - 143, but it was at par with RF -125. In the experiment investigation yield and yield attributes viz. number of number of seeds umbel⁻¹ (Table 1) were studied. At irrigation level of 0.55 PE and 0.70 PE soil moisture content was very meagre which cause poor plant growth. Higher irrigation level (0.85 and 1.0 PE) helped to manage stress free conditions for optimum plant growth. The result also confirmed the findings of Bhunia *et al.* (2015) who reported positive effect of drip irrigation on enhancing yield attributes viz., pods plant⁻¹, pod length and seeds pod⁻¹ in fenugreek. Cultivars significantly influenced yield and yield attributes viz., number of seeds umbel⁻¹, studies comprised of five high yielding fennel varieties viz., RF-205, RF-125, RF-145, RF-178 and AF1. Highest number of seeds umbel⁻¹ was obtained from the energized AF1 followed by RF-205.

Seed yield

The highest seed yield was recorded under drip irrigation at 1.0 PE, which was at par with 0.85 PE. Irrigation with 1.0 PE recorded maximum seed yield (2304 kg ha⁻¹) as compared to 0.55 PE and 0.70 PE but it was statistically at par with 0.85 PE level of irrigation. Highest seed yield (2069 kg ha⁻¹) was recorded in RF-205 as compared to RF -

101, RF -125 and RF – 143. Crop irrigated at 1.0 PE recorded maximum Stover yield (4263 kg ha⁻¹) as compared to 0.55 PE and 0.70 PE but it was statistically at par with 0.85 PE irrigation level. The increased seed yield of fennel due to optimum moisture status in the root zone area throughout the crop growing periods which resulted higher relative leaf water, optimum growth, and increased yield attributes like umbels plant⁻¹ and seeds umbel⁻¹, enhancing seed yield of fennel compared to 0.55 PE and 0.70 PE. Increased in seed, stover, and biological yield with increasing irrigation levels reported by Mehta *et al.* (2010)^[6] and similar results were also reported by Solanki *et al.* (2017) in fennel.

Highest Stover yield (4126 kg ha⁻¹) was recorded in RF-205 as compared to RF - 101, RF -125 and RF – 143. Irrigation with 1.0 PE recorded significantly higher harvest index (35.09 per cent) over 0.55 PE, 0.70 PE and 0.85 PE levels of irrigation. Soil moisture stress at the stage of reproduction and seed development were seriously affected in fennel crop. The most critical stage of water deficient begins with the opening of pollen cell, which decide the total number of seed in umbels. The yield damage occurs on one critical stage by water stress, giving water on another critical stage to compensate does not matter. Similar studies were reported by Patel (2000)^[7] and Kanupara *et al.* (2016)^[4] in cummin. Cultivars significantly influenced yield and yield attributes *viz.*, seed, stover, and harvest index. Similar finding and was reported by Meena *et al.* (2017)^[5] studies comprised of five high yielding fennel varieties *viz.*, RF-205, RF-125, RF-145, RF-178 and AF1. Highest yield was obtained from the energized AF1 followed by RF-205.

Net returns: Economic analysis presented in Table 1 revealed that maximum net returns (129002 ₹ha⁻¹) was

recorded with irrigation treatment of 1.0 PE, which was at par with 0.85 PE (123947 ₹ha⁻¹). Minimum net returns of 56164 ₹ha⁻¹ were observed under irrigation level at 0.55 PE. Cultivar RF- 205 recorded significantly higher net returns (114670 ₹ha⁻¹) over RF- 101, RF- 125 and RF- 143. maximum B: C ratio (4.16) was recorded with irrigation treatment of 1.0 PE, which was at par with 0.85 PE (4.16). Minimum B: C ratio of 2.56 was observed under irrigation at 0.55 PE. B: C ratio was found significant due to different cultivars of fennel. Cultivar RF- 205 recorded significantly, higher B: C ratio (3.96) over RF- 101, RF- 125 and RF- 143. Among the irrigation levels the higher net returns was recorded at 1.0 PE levels followed by level of 0.85 PE because of higher yield at 1.0PE level. Patel (2000)^[7] reported that maximum net returns were realized in fennel by scheduling irrigation at an IW/CPE ratio of 1.0. In the case of B: C ratio maximum was recorded at 1.0 PE (4.16) compared to 0.55 and 0.70 PE but it was at par with 0.85 PE irrigation level. The total cost of crop production increased with increasing in PE levels. The irrigation cost included under experiment was low which led to more income under experiment. Similar result reported by Datta and Chatterjee (2006) found that the significantly higher net returns were recorded with 1.0 IW/CPE ratio but B:C ratio was higher with 0.8 IW/CPE ratio in fenugreek. Similar results were also reported by Bhunia *et al.* (2005)^[2] in fennel crop. The net returns and B: C was significantly affected by cultivars. Highest net returns and B: C ratio was recorded in variety of RF-205 followed by RF-125, RF-101 and RF-143. Net returns and B: C ratio were higher in variety RF-205 due to its high yield. Higher yielding variety directly related with net returns and B: C ratio.

Table 1: Revealed that maximum net returns (129002 ₹ha⁻¹)

Treatments	Number of seed umbel ⁻¹	Seed yield (Kg ha ⁻¹)	Stover yield (Kg ha ⁻¹)	Harvest index (%)	Net returns (₹ ha ⁻¹)	B:C ratio
Irrigation levels						
0.55 PE	144.57	1229	3073	28.54	56164	2.56
0.70 PE	185.07	1803	3517	33.90	95644	3.54
0.85 PE	211.93	2211	4201	34.48	123947	4.16
1.00 PE	221.57	2304	4263	35.09	129002	4.16
SEm±	5.47	53	101	0.13	3924	0.10
CD at 5%	18.92	184	349	0.46	13580	0.35
Cultivars						
RF -101	184.15	1821	3617	33.07	96276	3.47
RF -125	195.24	1865	3722	32.88	99555	3.56
RF -143	174.25	1793	3588	32.95	94257	3.43
RF -205	209.48	2069	4126	33.11	114670	3.96
SEm±	5.85	39	76	0.07	2907	0.07
CD at 5%	17.07	115	222	NS	8485	0.22

Conclusion

On the basis of one season experimentation, it may be concluded that the irrigation levels 1.0 PE significantly enhanced the yield, net returns and B: C ratio over 0.55 and 0.70 PE levels but remained at par with 0.85 PE irrigation level. Highest net returns (129002.08) recorded at 1.00 PE levels which is closely related with 0.85 PE levels. Cultivar RF -205 showed highest yield and yield attributes, net returns and B: C ratio followed by RF-125, RF-101 and RF-143 cultivars of fennel.

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