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# Effect of irrigation levels on yield, water use, water use efficiency and NPK uptake of fennel (*Foeniculum vulgare* Mill.) cultivars grown under drip system

**Bharti Devi, SR Bhunia, Sunita and Sarita**

**Abstract**
A field experiment was conducted at Instructional Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner in *rabi* season 2019-20 to study the response of fennel (*Foeniculum vulgare* Mill.) to irrigation levels and crop geometry grown under drip system. The results showed that irrigation at 1.0 PE gave maximum number of umbels per plant, number of umbellate per umbel, test weight, seed yield, biological yield, nitrogen content and uptake but all these parameters were at par with 0.80 PE. at 0.60 PE gave highest water use efficiency irrigation level.

**Keywords:** Crop geometry, irrigation, growth, yield etc.

## Introduction
Fennel (*Foeniculum vulgare Mill*.) an important seed spice in India is mainly grown in Rabi season. It is locally called "saunf" and belongs to family Apiaceae or Umbelliferae. Fennel is a native of Southern Europe and Asia minor. It is a biennial herb but it is grown as a pleasantly aromatic annual herb with feathery leaves and golden yellow flowers and each part of it (leaves, stalks, bulbs and seeds) is edible. The aroma is due to the presence of volatile oils *viz.* Anethole and Fenchone. The seeds contain about 9.5% protein, 10.0% fat, 42.3% carbohydrates, 18.5% fibre and 13.4% minerals and about 0.7% to 6.0% volatile oil depending on genotypes or botanical types (Bhunia *et al*., 2005) [2]. The volatile oils of fennel are used to control flatulent dyspepsia and colic in children (Mahfouz and Sharaf-Eldin, 2007).
Fennel is cultivated mostly in Russia, Rumania, Hungary, Germany, France, Italy, India, Japan, Argentina, and USA. In India, it is chiefly cultivated in the states of Gujarat and Rajasthan and some areas in Uttar Pradesh, Karnataka A.P., Punjab and M.P. as a rabi crop. Rajasthan and Gujarat are known as the "seed spices bowl" of the country. India is the leading producer of fennel with an area of about 75.26 thousand hectare and production of 127.79 thousand tones and productivity of 22.33 q ha. (Anonymous 2019) [1]. Rajasthan occupies 30.67-thousand-hectare area and production is 32.29 thousand tones (Anonymous, 2019) [1]. About 33% of total country production is being contributed by Rajasthan.
Fennel being a wide spaced crop can be grown successfully under drip system in water scarce states like Rajasthan. Drip irrigation can be an important tool in increase fennel yield substantially by maintaining moisture content in soil at near about field capacity in one hand and by also eliminating water losses on the other hand. Thus, adoption of drip irrigation in fennel can save huge amount of irrigation water which can be used for horizontal increase of irrigation areas.
In arid western Rajasthan, drip irrigation on the basis of climatological approach gaining great promise for minimizing water loss and improving water utilization efficiency and yield. The PE approach permits the formation of irrigation time tables for different crops. Evapotranspiration based scheduling of irrigation is a proper and scientific to provide required irrigation water through drip system for harnessing potential yield of fennel crop. There is a need to work out optimum irrigation schedule based on various PE levels for optimum utilization of limited water resources of this state. For optimum moisture content of soil which maintains proper soil structure or physical condition, it is important to work out irrigation schedule It is there for felt that for ensuring higher productivity of *rabi* fennel, suitable irrigation levels involving drip irrigation in conjuction with appropriate crop geometry need to developed for arid and semi-arid conditions of Rajasthan.

## Materials and Methods

A field experiment was conducted at Instructional Farm, College of Agriculture, S.K. Rajasthan Agricultural University, Bikaner (Raj.) during *rabi* season of 2019-20. Bikaner is situated at 28.010N latitude and 73.220 E longitude at an altitude of 234.70 meters above mean sea level. 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 $ha^{-1}$).

The experiment was laid out in split plot design and replicated thrice. The treatments comprised of four irrigation levels *viz*. 0.40, 0.60, 0.80 and 1.0 PE in the main plot, three crop geometry *viz*. normal sowing at 50 cm x 20 cm row spacing, wide row sowing at 100 cm x 10 cm and paired row sowing at 30 cm x 70 cm in the sub-plot. Sowing was done by dibbling method using seed rate 10 kg $ha^{-1}$ at the depth of 2-3 cm. Recommended dose of N and $P_2O_5$ 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). The scheduling of irrigation was done with 0.40, 0.60, 0.80 and 1.0 PE at alternate day irrigations were applied through drip. The irrigation water was calculated using pan evaporation data. Dripper discharge rate per hour and one dripper cover area per plot were calculated for applying irrigation water and then calculated 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*., 0.40, 0.60, 0.80 and 1.0 PE Other package of practices was followed as per recommendations made for the crop in region. The uptake of nitrogen and phosphorus after harvesting of seed was estimated by using the following relationship.

$$\text{Nutrient uptake (Kg ha}^{-1}) = \frac{\text{Nutrient content in seed (\%)} \times \text{Seed yield (Kg ha}^{-1}) + \text{Nutrient content in stover (\%)} \times \text{Stover yield (Kg ha}^{-1})}{100}$$

The seed yield of respective plot was added to Stover yield to record biological yield per plot and finally presented as kg $ha^{-1}$. One thousand seeds were counted from the sample drawn from finally winnowed and cleaned produce of each net plot and weight in grams was recorded separately for each net plot by electronic balance. It was calculated as the ratio of seed yield to total water used in the particular treatment and expressed in kg $ha^{-1}$ $mm^{-1}$.

$$\text{WUE (kg ha}^{-1}\text{ mm}^{-1}) = \frac{\text{Seed yield (kg ha}^{-1})}{\text{Water used (mm)}}$$

## Result and discussion

### Yield attributes and yield

In the investigation yield and yield attributing characters *viz*. number of umbels $plant^{-1}$, number of umbellates $umbel^{-1}$, test weight, seed yield, biological yield, water use and water use efficency were studied. Irrigation schedules significantly influenced yield attributes and yield of fennel. All these parameters increased with increasing levels of irrigation from 0.40 to 1.0 PE through drip. Irrigation at 1.0 PE recorded highest number of umbels $plant^{-1}$(28.85), number of umbellates $umbel^{-1}$(27.30), and test weight (7.36 g), seed yield (1731 kg $ha^{-1}$), biological yield (5225kg $ha^{-1}$), water use(1061.50mm), which were at par with 0.80 PE. At irrigation levels of 0.40 and 0.60 PE, water availability was very scanty which caused plant mortality as well as poor growth. The maximum water use efficiency was recorded at 0.60 PE (2.80 kg $ha^{-1}$ $mm^{-1}$) under drip irrigation. Higher irrigation levels (0.80 and 1.0 PE) helped in maintaining the stress free conditions for optimum growth and development of plants throughout the crop growing period. The results corroborate with the findings of Datta and Chatarjee (2006) [5] who reported higher seed yield of fenugreek with 1.0 IW/CPE ratio. The above Fennel yield components significantly influenced by crop geometry. Highest number of yield attributes were recorded with paired row sowing at 30 cm x 70 cm spacing. Proper paired rowed geometry facilitates sufficient interception of sunlight and adequate absorption of nutrients and water from the soil due to proper development of root system (Annadurai *et al*., 2009). Yadav *et al*. (2000) [7] also reported higher yield attributes with optimum crop geometry of fennel.

### Chemical analysis

### Nitrogen and Phosphorus uptake in seed, stover and total uptake

It is apparent from the data (Table 2) that nitrogen uptake by fennel seed increased significantly with increasing levels of irrigation. The highest N content (1.49%) in seed was recorded with 1.0 PE but remained at par with 0.80 PE level of irrigation and significantly superior to 0.40 PE and 0.60 PE. Significantly highest N content (0.704%) in stover was recorded with 1.0 PE level of irrigation compared to 0.40 PE and 0.60 PE but remained at par with 0.80 PE. Maximum phosphorus content in the seed (0.485%) and stover (0.169%) was recorded with 1.0 PE, which was significantly superior to 0.40 and 0.60 PE, but was at par with 0.80PE. Significantly highest N uptake by seed (25.81 kg $ha^{-1}$) and stover (25.49 kg $ha^{-1}$) and total N uptake (51.30 kg $ha^{-1}$) by crop recorded with 1.0 PE level of irrigation compared to 0.40 and 0.60PE but remained at par with 0.80 PE level of irrigation. Significantly highest P uptake by seed (8.60 kg $ha^{-1}$) and stover (6.14 kg $ha^{-1}$) and total P uptake (14.74 kg $ha^{-1}$) was recorded with 1.0 PE level of irrigation which were significantly superior to 0.40 and 0.60 PE but was at par with 0.80 PE level of irrigation. Paired row sowing at 30 cm x 70 cm recorded maximum phosphorus content in seed and stover and at par with 50 cm x 20 cm row spacing and superior over wide row sowing at 100 cm x 10 cm. Significantly higher N and P uptake by seed and stover and total uptake were recorded higher with paired row sowing at 30 cm x 70 cm compared to normal sowing at 50 cm x 20 cm row spacing and superior over wide row sowing at 100 cm x 10 cm.

**Table 1:** Effect of irrigation levels and crop geometry on number of umbels per plant and umbellate per umbel in fennel, test weight, seed yield, biological yield, Water use (mm), Water use efficiency (kgha-1 mm)

| Treatments | Number of umbels plant$^{-1}$ | Number of umbellate umbel$^{-1}$ | Test weight (g) | Seed | Biological | Water use (mm) | Water use efficiency (kgha$^{-1}$ mm) |
|---|---|---|---|---|---|---|---|
| 0.40 PE | 21.28 | 19.86 | 6.37 | 1287 | 4529 | 469.84 | 2.74 |
| 0.60 PE | 25.78 | 24.41 | 6.78 | 1549 | 5001 | 667.06 | 2.80 |
| 0.80 PE | 28.05 | 26.94 | 7.22 | 1679 | 5124 | 864.28 | 1.94 |
| 1.00 PE | 28.85 | 27.30 | 7.36 | 1731 | 5225 | 1061.50 | 1.63 |
| SEM ± | 0.63 | 0.47 | 0.17 | 19.70 | 104.11 | - | 0.04 |
| CD at 5% | 2.19 | 1.63 | NS | 68.20 | 360.64 | - | 0.13 |
| **Crop geometry** | | | | | | | |
| Normal sowing (50 cmx20 cm) | 25.70 | 24.94 | 6.84 | 1564 | 4886 | 765.67 | 2.25 |
| Wide sowing(100cmx10cm) | 25.06 | 23.33 | 6.83 | 1518 | 4766 | 765.67 | 2.18 |
| Paired sowing (30 cmx 70 cm) | 27.19 | 26.06 | 7.13 | 1598 | 5257 | 765.67 | 2.42 |
| SEM ± | 0.38 | 0.21 | 0.05 | 16.59 | 83.90 | - | 0.03 |
| CD at 5% | 1.14 | 0.62 | 0.16 | 49.73 | 251.53 | - | 0.08 |

**Table 2:** Effect of irrigation levels and crop geometry on nitrogen content and uptake of fennel seed and stover

| Treatments | Nutrient content (per cent) | | | | Nitrogen uptake (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|
| | Nitrogen | | Phosphorus | | | | |
| | Seed | Stover | Seed | Stover | seed | Stover | Total uptake |
| 0.40 PE | 1.30 | 0.627 | 0.353 | 0.141 | 16.91 | 18.29 | 35.20 |
| 0.60 PE | 1.43 | 0.675 | 0.408 | 0.154 | 22.21 | 22.88 | 45.09 |
| 0.80 PE | 1.47 | 0.688 | 0.470 | 0.165 | 24.75 | 24.41 | 49.16 |
| 1.00 PE | 1.49 | 0.704 | 0.485 | 0.169 | 25.81 | 25.49 | 51.30 |
| SEM ± | 0.03 | 0.012 | 0.009 | 0.003 | 0.57 | 0.91 | 1.17 |
| CD at 5% | 0.10 | 0.041 | 0.031 | 0.009 | 1.96 | 3.13 | 4.05 |
| **Crop geometry** | | | | | | | |
| Normal sowing (50 cmx20 cm) | 1.42 | 0.673 | 0.426 | 0.153 | 22.80 | 22.68 | 45.48 |
| Wide sowing(100cmx10cm) | 1.40 | 0.662 | 0.420 | 0.150 | 21.14 | 21.30 | 42.45 |
| Paired sowing (30 cmx 70 cm) | 1.45 | 0.685 | 0.442 | 0.169 | 23.31 | 24.33 | 47.69 |
| SEM ± | 0.02 | 0.006 | 0.004 | 0.002 | 0.35 | 0.58 | 0.67 |
| CD at 5% | 0.05 | 0.018 | 0.012 | 0.007 | 1.04 | 1.73 | 2.01 |

## Conclusion

Based on the investigation it is concluded that application of irrigation at 1.0 PE with paired row sowing of 30 cm × 70 cm recommended for fennel for higher production in the arid and semi-arid region of Rajasthan.

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