

Growth and yield of fennel (*Foeniculum vulgare* Mill.) as influenced by irrigation, nutrient levels and crop geometry

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Abstract

A field experiment was conducted during 2003-06 at Ajmer (Rajasthan) to study the growth, profitability and productivity of fennel (*Foeniculum vulgare*) as influenced by irrigation (12, 15 and 18 days interval), nutrients levels (N and P₂O₅ each at 60/30, 90/40 and 120/50 kg ha⁻¹) and crop geometry (40 cm x 25 cm, 50 cm x 25 cm and 60 cm x 25 cm). Significantly higher yield attributes, seed yield and N, P and K uptake was obtained with 15 days irrigation interval. Growth parameters, yield attributes, yield and N, P and K uptake were significantly higher with application of 120 kg N and 50 kg P₂O₅ ha⁻¹. Crop geometry of 60 cm x 25 cm resulted in significantly higher seed yield. Thus, irrigation at 15 days interval with 120 kg N and 50 kg P₂O₅ ha⁻¹ at 60 cm x 25 cm was optimum for realizing higher yield, profitability and productivity of fennel.

Keywords: crop geometry, fennel, *Foeniculum vulgare*, irrigation, nutrition.

The limited quantity of water available in Rajasthan for irrigation calls for an urgent need for application of water at appropriate intervals for ensuring better water use efficiency. Maintenance of optimum plant population is essential for interception of solar radiation without exerting competition for nutrients and water in various crops. Little information on integrated management of nutrients and water along with crop geometry is available in fennel (*Foeniculum vulgare* Mill.), a major seed spice, which is extensively cultivated in Rajasthan. Thus, the present investigation was carried out to find out the optimum irrigation interval, fertilizer dose and crop geometry in fennel.

The field experiment was conducted at National Research Centre on Seed Spices, Ajmer

(Rajasthan) (74° 35' 39" to 74° 36' 01" E longitude and 26° 22' 12" to 26° 22' 31" N latitude; altitude : 460.17 m above MSL) during three consecutive *rabi* seasons of 2003-06. The soil of the experimental site was sandy loam with a pH of 8.92 having 0.21% organic carbon and 76.0, 33.4, and 234.1 kg ha⁻¹ available N, P₂O₅ and K₂O, respectively. The rainfall is confined mostly between July to September, averaging between 250-500 mm with a maximum of 750 mm in good rainy years and 50-200 mm in scanty rainy years. The experiment was laid out in a split-split plot design with three levels of irrigation (I₁-12 days interval, I₂-15 days interval and I₃-18 days interval) in main plot, three doses of nitrogen and phosphorus (N and P₂O₅ each at 60/30, 90/40 and 120/50 kg ha⁻¹, respectively) as sub-plot treatments and three crop geometry

(40 cm x 25 cm, 50 cm x 25 cm and 60 cm x 25 cm) as sub-sub plot treatment and replicated thrice. Sowing of fennel (var. Ajmer Fennel-1) using 10 kg seed ha⁻¹ was done at 60, 50 and 40 cm line to line spacing, keeping 25 cm plant to plant distance. Immediately after sowing, light irrigation was applied for ensuring germination and establishment of the crop. Afterwards each irrigation of 50 mm depth (measured with Pashall flume 7.5 mm throat placed at the head irrigation channel) was provided as per irrigation intervals under study. Thus 10, 8 and 6 irrigations were provided in 12, 15 and 18 days irrigation interval, respectively. Half of total nitrogen and full dose of phosphorus under study was provided at the time of sowing and remaining half nitrogen was divided in two equal splits and applied at 30 and 60 days after sowing, respectively. Nitrogen and phosphorus were supplied through urea and DAP, respectively. Five plants were selected randomly from each plot and their dry weight was taken after drying in oven at 70°C till constant weight was obtained. The concentration of N in plant at various growth stages was determined by the procedure suggested by Snell & Snell (1949) and of P and K content by methods suggested by Jackson (1973). Nutrient accumulation plant⁻¹ day⁻¹ was determined by multiplying nutrient with dry matter accumulation day⁻¹. Observations on plant height, branches plant⁻¹ and yield attributing characters namely, umbels plant⁻¹, umbellates umbel⁻¹, and seeds umbellate⁻¹ at harvest and yield were recorded.

Growth

Irrigation significantly influenced number of branches plant⁻¹ and dry matter accumulation plant⁻¹. Application of irrigation at 12 days interval resulted in higher plant height but higher dry matter accumulation and branches plant⁻¹ were recorded with irrigation at 15 days interval. Significant increase in plant height, branches plant⁻¹ and dry matter accumulation was obtained with increase in nitrogen and phosphorus levels. Application of 120/50 kg ha⁻¹ N/ P₂O₅ gave significantly the highest plant height and branches plant⁻¹ at harvest. The increase in plant height and dry matter

accumulation was in conformity with the finding of Patel *et al.* (2007). Close spacing in fennel promoted height but dry matter accumulation plant⁻¹ as well as branches plant⁻¹ were significantly higher at 60 cm x 25 cm row to row and plant to plant spacing, which was on par with 50 cm x 25 cm spacing (Table 1). Similar results were reported by Yadav *et al.* (2000) in fennel.

Yield attributes

Maximum number of umbels plant⁻¹, seeds umbellate⁻¹, umbellates umbel⁻¹, test weight and seed yield plant⁻¹ were produced when the crop received irrigation at 15 days interval which was on par with 18 days irrigation interval. Application of 120 and 50 kg ha⁻¹ N and P₂O₅ produced significantly higher umbels plant⁻¹, seeds umbellate⁻¹, umbellates umbel⁻¹ and seed yield plant⁻¹, respectively, over 60 and 30 kg N and P₂O₅. These results are in conformity with Patel *et al.* (2000) who obtained higher yield attributes and yield of fennel with application of higher levels of N and P₂O₅ with irrigation at 1.0 IW/CPE ratio. Crop geometry of 60 cm x 25 cm resulted in significantly higher yield attributes over 50 cm x 25 cm and 40 cm x 25 cm row to row and plant to plant spacing (Table 1). Yadav *et al.* (2000) also reported higher yield attributes with higher crop geometry in fennel.

Yield

Irrigation at 15 days resulted in increased growth and development attributes which significantly increased seed, straw and biological yield of fennel over irrigation at 12 and 18 days interval. The highest seed yield (1663 kg ha⁻¹) was obtained with irrigation at 15 days interval (Tables 1). The highest biological yield (3749 kg ha⁻¹) was also recorded with irrigation at 15 days interval but harvest index was not influenced with irrigation levels. Application of increasing levels of N and P enhanced vegetative growth and thus yield attributes which resulted in increase in seed and biological yield of fennel. Increase in seed yield with increased levels of N and P and irrigation at 1.0 IW/CPE ratio was also reported by Patel *et al.* (2000; 2007). Significantly higher seed,

Table 1. Effect of irrigation, fertility levels and crop geometry on growth parameters, yield attributes and yield of fennel (Pooled data of 2003-06)

| Treatment | Plant height (cm) | DMA plant ⁻¹ (g) | No of branches plant ⁻¹ | Umbels plant ⁻¹ | Seeds umbellate ⁻¹ | Umbellates umbel ⁻¹ | Test weight (g) | Seed yield plant ⁻¹ (g) | Straw yield (kg ha ⁻¹) | Biological yield (kg ha ⁻¹) | Harvest index (%) |
|---------------------------------------|-------------------|-----------------------------|------------------------------------|----------------------------|-------------------------------|--------------------------------|-----------------|------------------------------------|------------------------------------|---|-------------------|
| Irrigation interval | | | | | | | | | | | |
| 12 days | 148.34 | 72.35 | 20.89 | 32.54 | 24.39 | 22.30 | 7.35 | 31.04 | 1830 | 3251 | 42.06 |
| 15 days | 146.38 | 73.69 | 22.99 | 35.62 | 26.49 | 25.73 | 8.69 | 33.67 | 2087 | 3749 | 44.34 |
| 18 days | 143.36 | 72.93 | 21.71 | 34.45 | 25.21 | 24.50 | 7.93 | 32.60 | 1960 | 3518 | 44.26 |
| SEm± | 2.49 | 1.22 | 0.36 | 0.56 | 0.41 | 0.37 | 0.13 | 0.53 | 32 | 57 | 0.94 |
| CD (P=0.05) | NS | NS | 1.40 | 2.19 | 1.63 | 1.47 | 0.50 | 2.09 | 125 | 224 | NS |
| N/P ₂ O ₅ level | | | | | | | | | | | |
| 60/ 30 kg ha ⁻¹ | 142.31 | 71.92 | 20.61 | 32.02 | 24.11 | 22.05 | 6.92 | 30.52 | 1770 | 3151 | 42.18 |
| 90/40 kg ha ⁻¹ | 145.99 | 72.93 | 21.98 | 34.29 | 25.48 | 23.95 | 7.93 | 32.60 | 1966 | 3517 | 44.07 |
| 120/50 kg ha ⁻¹ | 149.77 | 74.13 | 23.02 | 36.29 | 26.52 | 26.52 | 9.13 | 34.19 | 2140 | 3850 | 44.40 |
| SEm± | 2.20 | 1.10 | 0.33 | 0.52 | 0.39 | 0.36 | 0.12 | 0.49 | 30 | 53 | 0.94 |
| CD (P=0.05) | 6.79 | NS | 1.03 | 1.59 | 1.19 | 1.12 | 0.37 | 1.52 | 92 | 164 | NS |
| Crop geometry | | | | | | | | | | | |
| 40 cm x 25 cm | 150.60 | 72.48 | 20.77 | 32.59 | 24.27 | 22.58 | 7.48 | 31.09 | 1806 | 3234 | 44.09 |
| 50 cm x 25 cm | 145.91 | 72.97 | 21.85 | 34.07 | 25.35 | 24.05 | 7.97 | 32.26 | 1944 | 3482 | 42.53 |
| 60 cm x 25 cm | 141.57 | 73.53 | 22.98 | 35.95 | 26.48 | 25.89 | 8.53 | 33.97 | 2128 | 3803 | 44.03 |
| SEm± | 2.20 | 1.08 | 0.33 | 0.71 | 0.47 | 0.35 | 0.12 | 0.46 | 29 | 51 | 0.92 |
| CD (P=0.05) | 6.79 | NS | 1.24 | 2.05 | 1.35 | 1.00 | 0.34 | 1.32 | 82 | 145 | NS |

DMA=Dry matter accumulation

Table 2. Effect of irrigation and fertility levels with varying crop geometry on returns, benefit : cost ratio and N, P and K uptake in fennel (Pooled data of 2003-06)

| Treatment | Cost of cultivation (Rs ha ⁻¹) | Gross returns (Rs ha ⁻¹) | Net returns (Rs ha ⁻¹) | BCR | N uptake (kg ha ⁻¹) | P uptake (kg ha ⁻¹) | K uptake (kg ha ⁻¹) |
|---------------------------------------|--|--------------------------------------|------------------------------------|------|---------------------------------|---------------------------------|---------------------------------|
| Irrigation interval | | | | | | | |
| 12 days | 27,100 | 56,852 | 29,752 | 1.10 | 35.70 | 9.04 | 60.96 |
| 15 days | 25,100 | 66,505 | 41,405 | 1.65 | 39.93 | 10.56 | 70.39 |
| 18 days | 23,767 | 62,311 | 38,544 | 1.62 | 35.87 | 9.89 | 66.04 |
| SEm± | 455 | 1003 | 557 | 0.02 | 0.63 | 0.16 | 1.07 |
| CD (P=0.05) | 1787 | 3938 | 2187 | 0.08 | 2.46 | 0.63 | 4.20 |
| N/P ₂ O ₅ level | | | | | | | |
| 60/30 kg ha ⁻¹ | 24,595 | 55,235 | 30,640 | 1.26 | 33.25 | 8.78 | 59.10 |
| 90/40 kg ha ⁻¹ | 25,100 | 62,039 | 36,939 | 1.49 | 37.25 | 9.86 | 66.00 |
| 120/50 kg ha ⁻¹ | 26,272 | 68,395 | 42,123 | 1.61 | 41.01 | 10.86 | 72.30 |
| SEm± | 392 | 942 | 558 | 0.02 | 0.57 | 0.15 | 1.00 |
| CD (P=0.05) | 1207 | 2901 | 1718 | 0.07 | 1.77 | 0.46 | 3.08 |
| Crop geometry | | | | | | | |
| 40 cm x 25 cm | 25,322 | 57,123 | 31,801 | 1.26 | 34.29 | 9.07 | 60.69 |
| 50 cm x 25 cm | 25,322 | 61,519 | 36,196 | 1.44 | 36.93 | 9.77 | 65.34 |
| 60 cm x 25 cm | 25,322 | 67,027 | 41,704 | 1.66 | 40.29 | 10.65 | 71.36 |
| SEm± | 385 | 936 | 553 | 0.01 | 1.08 | 0.29 | 1.85 |
| CD (P=0.05) | 1108 | 2686 | 1587 | 0.04 | 3.09 | 0.82 | 5.30 |

BCR=Benefit : cost ratio

straw and biological yield was recorded with crop geometry of 60 cm x 25 cm. Higher seed yield with higher row to row spacing was also reported by Yadav *et al.* (2000) in fennel.

Nutrient uptake and economics

Irrigation and N and P₂O₅ levels significantly influenced N, P and K uptake, net returns and benefit : cost ratio (Table 2). N, P and K uptake as well as net return and benefit : cost ratio (BCR) increased with increasing levels of N + P₂O₅. The above parameters were the highest with application of 120 kg ha⁻¹ N + 50 kg ha⁻¹ P₂O₅. Irrigation at 15 days interval was superior with respect to nutrient uptake, net return and BCR. These results are in conformity with the findings of Patel *et al.* (2000) and (Yadav *et al.* 2000).

The present study thus indicated that irrigation at 15 days interval and application of 120 kg ha⁻¹ N + 50 kg P₂O₅ ha⁻¹ with 60 cm x 25 cm crop geometry is optimum for realizing higher yield, profitability and productivity of fennel at Rajasthan.

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