

Influence of irrigation and fertilizer levels on growth, seed yield and water-use efficiency by fennel (*Foeniculum vulgare*)

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ABSTRACT

The field experiment was conducted during 1997-99 at New Delhi, to study growth, seed yield and water use by fennel (*Foeniculum vulgare* Mill.) under various levels of irrigation and fertilizer. Application of 3 irrigations at branching flowering and seed-filling stages, being at par with 2 irrigations at branching and seed-filling stages, was superior to the remaining irrigation levels for umbels/plant, seeds/umbel, seed yield /plant and seed yield/ha. Water use and water-use efficiency were maximum with 3 irrigations at branching, flowering and seed filling and 2 irrigations at branching and seed-filling stages treatments respectively. Recommended dose of fertilizers and half of recommended dose of fertilizers with FYM @ 10 tonnes/ha being similar, recorded taller plants and more branches/plant, umbels/plant, seeds/umbel, seed yield/plant and seed yield/ha. Highest water use and water-use efficiency and 1,000-seed weight were also recorded with the recommended dose of fertilizers.

Key words : Fennel, *Foeniculum vulgare*, Irrigation, Fertilizer, Water-use efficiency

Fennel is an important seed spice grown in northern part of the country under limited irrigation conditions. Adequate use of irrigation and appropriate application of fertilizers play a vital role in improving the productivity and quality of fennel. The proper utilization and timely application of resources depend on the management capacity of the grower, which results in higher production. It is therefore essential to evaluate the critical growth stages, viz. branching, flowering and seed-filling stages, where the crop should be irrigated

along with variable levels of fertilizers.

MATERIALS AND METHODS

The field experiment on fennel with 5 irrigation levels based on physiological stages, viz. no irrigation, 1 irrigation at branching (B), 2 irrigations at branching and flowering (B+F), 2 irrigations at branching and seed filling (B+SF) and 3 irrigations at branching, flowering and seed filling (B+F+SF) in main plots; and 4 fertilizer levels, viz. control, recommended dose of fertilizes (RDF), half of RDF and

half of RDF plus farmyard manure (FYM) @ 10 tonnes/ha, in subplots was conducted during the winter (*rabi*) seasons of 1997-98 and 1998-99 at New Delhi. The experiment was laid out in split-plot design and replicated thrice. The loamy soil of the experimental field had 215 kg/ha, 10.5 kg/ha and 210 kg/ha available N, P and K, respectively, with the pH 8.1.

After applying a pre-sowing irrigation, the 'UF 101' cultivar of fennel was sown on 26 October 1997 and 16 October 1998 and harvested on 20 May 1998 and 25 May 1999, respectively. The row-to-row spacing of 60 cm and plant-to-plant spacing of 20 cm were maintained between the plants. The recommended dose of fertilizers (RDF) applied to fennel was 80 kg N, 50 kg P_2O_5 and 50 kg K_2O /ha. Irrigations and fertilizers were applied to the crops as per the treatments. The observations on various growth parameters at harvest and yield attributes were taken from the 5 plants, tagged in the second row of each plot. To study the water use, soil samples up to 120 cm soil depth were taken at sowing and harvesting and before and after each irrigation as per treatment from 1 replication only.

RESULTS AND DISCUSSION

Growth parameters

The growth parameters, viz. plant height and branches/plant at harvest stage were influenced significantly by the irrigation levels (Table 1). All the irrigated treatments had taller plants and more branches/plant than the unirrigated control. Three irrigations at B+F+SF stages, being at par with both of 2 irrigations levels at B+F and

B+SF stages recorded maximum plant height and branches/plant, which were significantly more than 1 irrigation (B). Application of 2 irrigations at B+SF stages also had taller plants and more branches/plant than those under 1 irrigation (B). The application of irrigation water at various stages, especially at branching stage, might have resulted in more available water to crop plants at that stage for various physiological processes like nutrient uptake, photosynthesis, which ultimately increased the growth of crop.

Fertilizer levels also influenced the plant height and branches/plant (Table 1). The treatment of RDF and half RDF + FYM @ 10 tonnes/ha being at par, recorded more plant height and branches/plant than half the RDF and the control. Marked improvement in plant height and branches/plant was also found with half the RDF alone over the control. More availability of nutrients at increased fertilizer levels might have enhanced meristematic activities and size of cells, and formation and functioning of protoplasm which consequently improved the crop growth. Our results confirm those of Ahmed *et al.* (1988) on growth in relation to N and P fertilization.

Yield attributes

Irrigation levels significantly affected the various yield-attributing characters, i.e. umbels /plant, seeds/umbel and seed yield/plant (Table 1). Application of either 1 or 2 or 3 irrigations resulted in more umbels/plant, seeds/umbel and seed yield/plant than unirrigated control. Three irrigations (B+F+SF), being similar to 2 irrigations (B+SF), were found superior to 1 irrigation

(B) for umbels/plant, seeds/umbel and seed yield/plant. More umbels/plant and seed yield/plant were also recorded with 2 irrigations at B+SF compared with 1 irrigation (B) and 2 irrigations at B+F stages. However, seeds/umbel were statistically equal with the application of 2 irrigations at B+F and B+SF stages, but were more than that at 1 irrigation (B). Higher physiological activities and more growth of crop plants with liberal water supply increased the umbels/plant and seeds/umbel owing to increasing partitioning of photosynthates to sink. Higher umbels/plant and seeds/umbel again improved the seed yield/plant. The 1,000-seed weight could not be influenced by irrigation levels (Table 1).

Umbels/plant, seeds/umbel, 1,000-seed weight and seed yield/plant were influenced significantly by fertilizer levels (Table 1). The RDF and half RDF + FYM @ 10 tonnes/ha fertilizer levels resulting in similar umbels/plant, seeds/umbel, 1,000-seed weight and seed yield/plant were superior to half RDF and the control. But the difference in 1,000-seed weight between half RDF and half RDF + FYM @ 10 tonnes/ha did not differ significantly. Half RDF also recorded more umbels/plant, seeds/umbel, 1,000-seed weight and seed yield/plant compared with the control. The sink capacity of the plant is dependent mainly on vegetative growth of plants. Vigorous vegetative growth in terms of branches/plant and plant height and more supply of photosynthates to sink at higher fertilizer levels benefited the yield attributes of fennel. Abdallah *et al.* (1978) also found the beneficial effect of NPK fertilizers on yield attributes of fennel.

Seed yield

In general, increase in seed yield of fennel because of 1 irrigation (B), 2 irrigations (B+F), 2 irrigations (B+SF) and 3 irrigations (B+F+SF) stages was 28.5, 50.2, 64.7 and 74.6 % over unirrigated control respectively (Table 2). Irrigation levels had significant effect on seed yield of fennel. Application of 3 irrigations (B+F+SF), being at par with 2 irrigations (B+SF) produced more seeds of fennel compared with remaining irrigation levels. However, the application of 2 irrigations at B+F and B+SF stages yielded similar but statistically more than that of 1 irrigation (B) and the control. One irrigation (B) also outyielded the control treatment. Increasing the number of irrigation enhanced the yield attributes like umbels/plant, seeds/umbel and seed yield/plant, which consequently improved the seed yield/ha with more number of irrigations. Sharma and Prasad (1990) also reported increased seed yield of fennel with more frequency of irrigation.

The application of half of RDF, full RDF and half of RDF plus FYM @ 10 tonnes/ha increased seed yield of fennel by 85.6, 43.1 and 79.4% over unfertilized control (Table 2). Fertilizer levels had the significant effect on seed yield of fennel. All the fertilized treatments yielded statistically more compared to unfertilized control. Full RDF, being at par with half RDF plus FYM @ 10/tonnes increased seed yield of fennel by 85.6, 43.1 and 79.4 % over unfertilized control (Table 2). Fertilizer levels had the significant effect on seed yield of fennel. All the fertilized treatments yielded statistically more compared to unfertilized control. Full RDF, being at

par with half RDF plus FYM @ 10 tonnes/ha gave the maximum seed yield. Similarly, half RDF plus FYM @ 10 tonnes/ha out yielded half of RDF fertilizer level. The application of full RDF and half of RDF plus FYM @ 10 tonnes/ha increased umbels/plant, seeds/umbel, 1,000-seed weight and seed yield/plant which consequently enhanced the seed yield/ha at these fertilizer treatments.

Table 1. Influence of irrigation and fertilizer levels on growth and yield attributes of fennel (pooled data of 1997-98 and 1998-99)

Treatment	Plant height (cm)	Branches/plant	Umbels/plant	Seeds/umbel	1,000-seed weight	Seed yield (g/plant)
<i>Irrigation</i>						
No irrigation	95.6	4.3	13.4	169	7.1	15.5
One irrigation (B)	103.7	6.8	16.4	178	7.3	20.7
Two irrigations (B+F)	107.7	7.6	17.6	189	7.6	23.4
Two irrigations (B+SF)	108.8	7.7	18.3	196	7.7	25.6
Three irrigations (B+F+SF)	109.3	7.8	18.8	202	7.8	26.6
CD (P=0.05)	5.0	0.9	0.7	7.3	NS	2.2
<i>Fertilizer</i>						
Control	84.6	4.1	15.1	158	6.7	15.9
RDF	116.3	8.3	18.3	208	8.1	26.6
Half RDF	103.8	6.9	16.5	179	7.2	21.5
Half RDF+FYM@ 10 t/ha	114.2	8.1	17.9	202	7.8	25.5
CD (P=0.05)	4.7	0.8	0.6	7.0	0.4	2.1

Table 2. Influence of irrigation and fertilizer levels on seed yield, water use and water-use efficiency by fennel (pooled data of 1997-98 and 1998-99)

Treatment	Seed yield (q/ha)	Water use (mm)	Water-use efficiency (kg/ha-mm)
<i>Irrigation</i>			
No irrigation	11.1	229.3	4.84
One irrigation (B)	14.2	283.0	5.02
Two irrigations (B+F)	16.6	331.3	5.01
Two irrigations (B+SF)	18.2	335.4	5.42
Three irrigations (B+F+SF)	19.3	374.2	5.16
CD (P=0.05)	2.4	-	-
<i>Fertilizer</i>			
Control	10.5	233.0	4.51
RDF	19.4	352.2	5.51
Half RDF	15.0	302.9	4.95
Half RDF+FYM@ 10 t/ha	18.8	354.3	5.31
CD (P=0.05)	2.2	-	-

Tomar *et al.* (1994) also recorded the maximum yield of coriander at highest NPK dose and beneficial effects of FYM and inorganic fertilizers on fennel were also advocated by Cavazza and Bianco (1975).

Water use

The maximum water use (374.2 mm) by fennel was recorded, when 3 irrigations were applied at B+F+SF stages (Table 2). Almost similar amount of water was used by the irrigation levels of 2 irrigations at B + F and B+SF stages. However, appreciably lower water use was recorded with 1 irrigation (B) level, being the minimum water use at unirrigated control.

Water-use efficiency

When 2 irrigations were applied at B+SF stages, the water-use efficiency was maximum (Table 2). Further increase in number of irrigations from 2 to 3 decreased the water-use efficiency because the yield increase due to increase in number of irrigations could not compensate for water use by crop at higher frequency of irrigation. Minimum water-use efficiency was recorded with no irrigation treatment (4.84 kg/ha-mm). For fertilizer levels,

maximum and minimum water-use efficiency were recorded with RDF and control fertilizer treatments respectively. The water-use efficiency of half RDF plus FYM @ 10 tonnes/ha was also very close to that of RDF (Table 2). Higher water-use efficiency at higher fertilizer levels can be attributed to the fact that there was relatively more increase in seed yield than crop water use at highest fertilizer levels.

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