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Influence of Drip Irrigation along with Nitrogen Levels on Yield Attributes, Yield and Quality Parameters of Rabi Drill Fennel (*Foeniculum vulgare* Mill)

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A B S T R A C T

A field experiment was conducted to study the effect of different levels of drip irrigation along with various nitrogen levels in drill fennel (Foeniculum vulgare Mill.) during rabi season of 2012-13 and 2013-14 at Junagadh Agricultural University, Junagadh. Sixteen treatment combinations comprising of drip irrigation at 0.6, 0.8 and 1.0 PEF and surface method of irrigation in main plot and four levels of nitrogen viz., 0, 60, 90 and 120 kg ha-1 in sub-plots were evaluated in split plot design with three replications. The study indicated better plant growth, number of umbels plant-1, number of umbellate umbel-1, number of seeds umbellate-1, 1000 seed weight, seed yield as well as stover yield and protein content in seeds of fennel. Drip Irrigation at 1.0 PEF (I3) recorded significantly the highest seed yield (1833 kg ha-1) and stalk yield (2867 kg ha-1) over drip irrigation at 0.6 PEF.

Introduction

Fennel (*Foeniculum vulgare* Mill) is one of the most important condiments of Gujarat and Rajasthan. Gujarat and Rajasthan together contributes about more than 80 per cent of the total seed spices production in the country and thus, both the states together are known as 'seed spices bowl' of India. It is commonly known as Saunf or Badi saunf in Hindi and Variari in Gujarati. India, the land of spices is the largest producer, consumer and exporter of spices in the world. The seed spices account for about 36% of total area and 17% of total production of spices in the country (Aishwath *et al.*, 2010). During 2012-13, the area, production and productivity of fennel in India was 99,723 ha, 1, 42,995 tonnes and 1.70 t ha^{-1} respectively (SBI, 2013). The crop stands third in area and production among seed spices in India and is mainly grown in the states of Gujarat, Rajasthan, Uttar Pradesh, Karnataka, Andhra Pradesh, Punjab and Madhya Pradesh, among the various factors contributing towards the attainment of potential yield and quality of fennel. Drip irrigation and nitrogen has considered practical importance. Therefore, an attempt of

drip irrigation and nitrogen levels on yield and quality of fennel.

Gujarat is the second leading producer of spices after Andhra Pradesh in the country. It occupies 26300 ha in area with production of 35800 tonnes and productivity of 1.36 t ha^{-1} during 2010-11 (DOA, 2011). In Gujarat, Mehsana district ranks first in area of (8200 ha), production (11600 tonnes) and productivity of (1410 kg ha^{-1}) of fennel (DOA, 2011).

Drip irrigation is a regulated and slow application of irrigation water through emitters at frequent intervals near the plant root zone over a long period of time. Adoption of drip irrigation helps to reduce the over exploitation of ground water that partly occurs because of inefficient use of water under surface methods of irrigation. It helps in saving of irrigation water, increases water / fertilizer use efficiencies, decrease tillage requirement and increased crop yields with higher quality produce. It is particularly suitable for irrigation with water of poor quality (saline water) irrigating daily pushes of the salt to the periphery of the moist zone (Rathore and Gaur, 2010).

Materials and Methods

An experiment was conducted at instructional farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during rabi seasons of 2012-13 and 2013-14. The experiment site is situated in South Saurashtra Agro-climatic region of Gujarat. The soil was medium clayey in texture and slightly alkaline in reaction with pH (8.01) and EC (0.31 dSm^{-1}), low in available N (241.2 kg ha^{-1}), medium in available P (22.44 kg ha^{-1}) and available K (242.2 kg ha^{-1}). The experiment comprising of three levels of drip irrigation and surface method (0.6, 0.8 and 1.0 PEF and 1.0 IW/CPE) and four levels of nitrogen (0, 60, 90 and 120 kg ha^{-1}) were laid out in split plot design with three replications. The fennel variety 'Gujarat Fennel-11' was sown at 45-15 cm paired rows. The crop was fertilized with 90-30-0 kg N-P_2O_5-K_2O/ha. The crop was raised as per the recommended package of practices. In drip system, laterals were laid out at 90 cm spacing (in between each paired row) and drippers (4 lit. hr^{-1} capacity) at 60 cm spacing. Drip irrigation was operated on alternate day at 1.2 kg $ha^{-1}cm^2$ pressure on the basis of pan evaporation fraction (PEF) of 0.6, 0.8 and 1.0. Flood irrigation each of 5 cm depth was scheduled on the basis of IW/CPE ratio 1.0.

Results and Discussion

Effect of irrigation on yield and yield attributes

Data presented in Table 1 indicated that different methods of irrigation significantly influenced yield attributes and yield of fennel. Significantly the highest plant height at 60, 90, 120 DAS and at harvest (92.01, 113.68, 127.86 and 140.58 cm), number of umbels plant-1 (22.58), umbellates umbel-1 (26.31) were recorded with drip irrigation at 1.0 PEF (I3) over drip irrigation at 0.6 PEF (I1). The quantum of water application through high pressure drip irrigation as well as low pressure drip system was same but it is the rate of flow of water that plays an important role for water movement in horizontal and vertically downward directions. In the low pressure drip system the discharge rate is slow that facilitate more downward movement of water through percolation hence horizontal spread is less. Similar results have also been reported by Lal *et al.,* (2013) in fenugreek. Bhunia *et al.,* (2005) also reported increased plant height, primary and secondary branches plant-1 with increasing levels of irrigation in fennel.

Drip irrigation at 1.0 PEF (I3) recorded significantly the highest number of seeds

umbellate-1 (28.27), 1000 seed weight (7.23 g), it remained at par with drip irrigation at 0.8 PEF (I2), respectively (Table 1). Conversely, drip irrigation at 0.6 PEF (I1) registered significantly the lowest values of these yield contributing parameters. In drip irrigation system, water is applied at a low rate for a longer period at frequent intervals near the plant root zone through lower pressure delivery system, which increase the availability of nutrient near the root zone with a reduction in leaching losses (Paul *et al.,* 2013). More nutrient availability, especially near the root zone might have increased the translocation of photosynthetes to storage organ of capsicum resulting in an increased weight of capsicum (Sankar *et al.,* 2008).

Seed and stover yield of fennel was significantly influenced by different methods of irrigation during the course of investigation (Table 2). Irrigating the fennel crop by drip irrigation at 1.0 PEF (I3) recorded significantly the maximum seed yield (1833 kg ha^{-1}) and stalk yield (2867 kg ha^{-1}) but it was remained at par with drip irrigation at 0.8 PEF (I2), respectively. Obviously, drip irrigation at 0.6 PEF (I1) produced significantly the lowest seed and stalk yields. In fact seed yield is the function of several yield components, which are depended on complementary interaction between vegetative and reproductive growth of crop. Results of present study are close related with the findings of Patel *et al.,* (2000), Bhunia *et al.,* (2005) in fennel and Rao *et al.,* (2010) in cumin also observed similar findings. The superiority of drip and micro sprinkler for these yield attributing parameters could be explained on the basis of moisture status and nutrients availability in the soil. In drip and micro sprinkler treatments, the soil remains moist and soft because of frequent irrigation on the basis of evapo-transpiration demand of the crop. These results are in conformity with the findings reported by Maheria *et al.,* (2012), Lal *et al.,* (2013).

Effect of nitrogen levels on yield and yield attributes

Data presented in Table 1 indicated that application of recommended dose of nitrogen 120 kg N ha^{-1} (N3) produced significantly enhanced plant height at 60, 90, 120 DAS and at harvest (85.71, 109.81, 125.35 and 135.79 cm), number of umbels plant-1 (19.24), which was found statistically at par with N2 (90 kg N ha^{-1}). Application of 120 kg N ha^{-1} recorded significantly the highest umbellates umbel-1 (25.23), number of seeds umbellate-1 (29.34), 1000 seed weight (7.13 g) over control. Since, yield of the crop is a function of several yield components which are dependent on complementary interaction between vegetative and reproductive growth of the crop. As these growth and yield attributes evidently resulted in higher yields under higher nitrogen levels. The present findings are in close agreement with the results obtained by Patel *et al.,* (2000) and Ehsanipour *et al.,* (2012). The increasing levels of N through drip restricted fertilizers to the wetted zone of soil where the active roots are concentrated thus, leads to better utilization of nutrients, their uptake and enhanced vegetative growth. The similar result of obtained by El- Mekawy *et al.,* (2012) and Ram Pratap *et al.,* (2010).

Fennel seed yield increased with increase in nitrogen levels Table 2. Application of 120 kg N ha^{-1} (N_3) recorded significantly the highest seed yield (1777 kg ha^{-1}) and stalk yield (2741 kg ha^{-1}) over control. Significantly increase in seed and straw yield under these nitrogen levels appears to be on account of their influence on dry matter production and indirectly via increase in plant height, number of branches $plant^{-1}$ and possibly a result of higher uptake of nutrients. The present findings are in close agreement with the results obtained by Patel *et al.,* (2000).

Table.2 Yield and quality parameters of fennel as influenced by different methods of irrigation and nitrogen levels. (Pooled over two years)

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Protein content in seed (%)	Oil content in seed (%)
Irrigation levels (I)					
I_1- 0.6 PEF	1129	2167	34.31	7.52	1.35
I_2- 0.8 PEF	1472	2500	37.03	8.15	1.42
I_3- 1.0 PEF	1833	2867	39.00	9.00	1.43
I_4- 1.0 IW/CPE	1222	2250	35.14	8.03	1.37
S.Em.±	32.62	49.26	0.95	0.15	0.03
C.D. at 5 %	100.50	151.77	2.91	0.45	NS
C.V. %	11.30	9.87	12.74	8.80	10.45
Nitrogen levels (N)					
N_0- Control	968	2168	32.65	7.20	1.35
N_1- 60 kg N ha^{-1}	1339	2340	35.82	8.06	1.38
N_2- 90 kg N ha^{-1}	1574	2535	38.15	8.46	1.42
N_3- 120 kg N ha^{-1}	1777	2741	38.85	8.99	1.42
S.Em.±	20.00	28.66	0.70	0.08	0.02
C.D. at 5 %	56.86	81.51	1.99	0.24	NS
C.V. %	6.93	5.74	9.44	5.00	7.34
Interaction I x N					
S.Em.±	39.99	57.33	1.40	0.17	0.04
C.D. at 5 %	113.71	163.01	3.98	0.47	NS

Fig.1 Harvest index and 1000-seed weight as influenced by irrigation and nitrogen levels

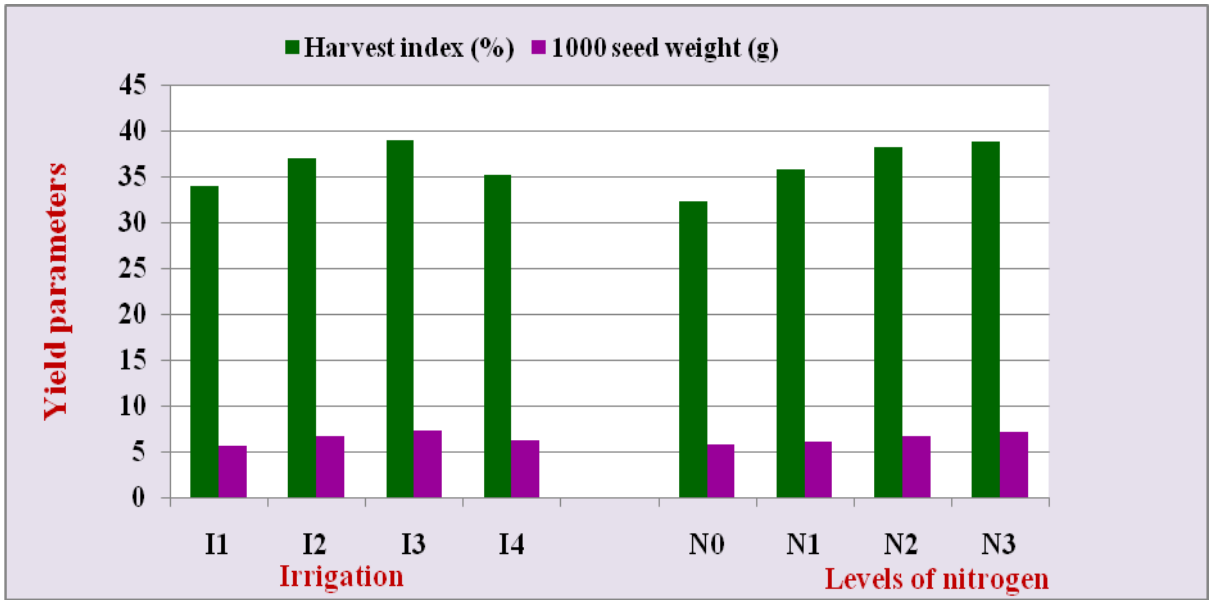
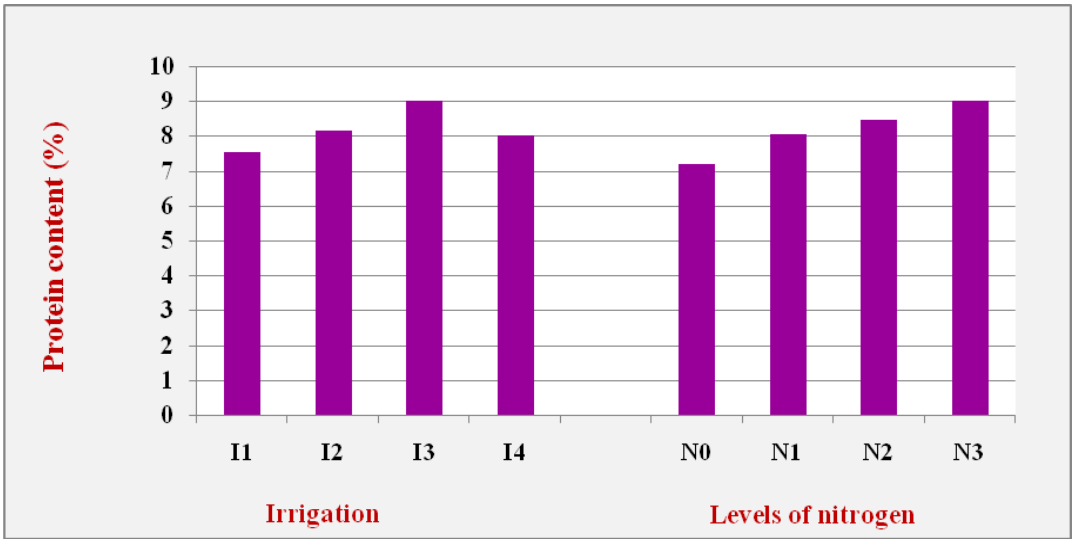


Table.1 Yield attributing parameters of fennel as influenced by different methods of irrigation and nitrogen levels. (Pooled over two years)

Treatments	Plant height (cm)				Number of umbels plant^{-1}	Umbellates umbel^{-1}	Number of seeds umbellate^{-1}	1000 seed weight (g)
	60 DAS	90 DAS	120 DAS	At harvest				
Irrigation levels (I)								
I_1- 0.6 PEF	67.43	92.22	108.82	121.42	15.18	17.82	19.74	5.61
I_2- 0.8 PEF	78.79	104.04	117.18	129.96	18.03	21.49	26.67	6.63
I_3- 1.0 PEF	92.01	113.68	127.86	140.58	22.58	26.31	28.27	7.23
I_4- 1.0 IW/CPE	72.38	97.96	113.86	122.79	16.30	19.28	24.65	6.28
S.Em.±	1.68	1.58	1.76	2.84	0.35	0.47	0.56	0.15
C.D. at 5 %	5.16	4.88	5.65	8.75	1.07	1.44	1.74	0.46
C.V. %	10.57	7.60	7.68	10.81	9.47	10.80	11.14	11.37
Nitrogen levels (N)								
N_0- Control	68.82	95.35	108.05	121.58	16.64	17.74	19.83	5.78
N_1- 60 kg N ha^{-1}	75.55	99.18	114.08	126.40	17.44	18.86	23.48	6.13
N_2- 90 kg N ha^{-1}	80.51	103.56	120.24	130.98	18.75	23.06	26.68	6.70
N_3- 120 kg N ha^{-1}	85.71	109.81	125.35	135.79	19.24	25.23	29.34	7.13
S.Em.±	1.35	1.37	1.35	2.50	0.33	0.38	0.45	0.11
C.D. at 5 %	3.83	3.90	3.83	7.10	0.93	1.09	1.28	0.32
C.V. %	8.50	6.59	5.65	9.51	8.87	8.81	8.88	8.51
Interaction I x N								
S.Em.±	2.69	2.74	2.70	5.00	0.65	0.76	0.90	0.22
C.D. at 5 %	7.66	7.80	7.67	14.21	1.85	NS	2.56	NS

Fig.2 Protein content as influenced by irrigation and nitrogen levels



Effect of irrigation on quality parameters

A perusal of data furnished in Table 2 revealed that quality parameters like oil content of seed was not influenced significantly due to drip irrigation treatments (Table 2). Protein content increased with increase in drip irrigation levels was found up to 1.0 PEF. Higher nitrogen in seed is directly responsible for higher protein because of increased N content in seed which might be the result of increased availability of nitrogen to plants. Another reason for higher nitrogen content might be due to increased activity of nitrate reductase enzyme. Higher nitrogen in seed is directly responsible for higher protein because it is a primary component of amino acids which constitute the basis of protein. Bhunia *et al.,* (2005) also observed similar findings.

Effect of nitrogen levels on quality parameters

Data presented in Table 2 indicated that oil content in seed was not influenced significantly by nitrogen levels (Table 2). Application of 120 kg N ha^{-1} recorded significantly the highest protein content in seed and it was found at par with application of 90 kg N ha^{-1}. Significantly the lowest protein content in seed was observed in control. The significant improvement in nutrient status of plant parts (seed and straw) might have resulted in greater synthesis of amino acid, proteins and growth promoting substances, which seems to have enhanced the meristematic activity and increased cell division and their elongation. Similar findings were also reported by Patel *et al.,* (2000) and Tuncturk (2011).

It can be concluded based on the pooled results of two-year experimentation, it is concluded that higher yield and protein content in seed production drip irrigation at 1.0 PEF along with 120 kg N ha^{-1} was found to be the optimum by recording higher values of growth and yield attributes, producing maximum seed yield of fennel in rabi season under water scarce conditions.

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