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Effect of drip irrigation and nitrogen levels on growth parameters and yield of drilled *rabi* fennel (*Foeniculum vulgare* Mill) in Saurashtra region of Gujarat

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Abstract: 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 to evaluate methods of irrigation (drip irrigation at 0.6, 0.8, 1.0 PEF and surface method) and levels of nitrogen (0, 60, 90 and 120 kg ha^{-1}) in *rabi* fennel. The results revealed that the drip irrigation at 1.0 PEF along with 120 kg N ha^{-1}) significantly improved growth and yield attributes viz., plant height, dry matter accumulation, days to flowering, branches plant^{-1}, umbels plant^{-1}, umbellate umbel^{-1} and test weight and thereby increased seed and stalk yields along with higher net returns over lower level of drip irrigation (0.6 PEF).

Key words: Drip irrigation, nitrogen, PEF, fennel, seed and stover yield

Introduction

Fennel (*Foeniculum vulgare* Mill) wild or cultivated is extensively present throughout the world which belongs to the celery family *Umbelliferae* and is believed to be native of Southern Europe and Mediterranean region. Fennel is mainly cultivated for its seeds (*saunf*) which have a pleasant fragrance and an aromatic taste. Its area under *rabi* drilled fennel is increasing because of its short duration and more profitable spice than other *rabi* crops like wheat, cumin, coriander, fenugreek, mustard etc. In spite of its huge demand and production potential in the country, the productivity of *rabi* drilled fennel is low (1200 kg ha^{-1}) as compared to its potential yield of 2500 kg ha^{-1} (Patel *et al*., 2000).

Water is most precious natural and scarce resource, vitally important for day to day living as well as sustainable agriculture development. Irrigation and fertilizers are costly and scarce inputs for crop production. Availability of irrigation water is limited and therefore, it should be utilized most efficiently by adopting latest irrigation technologies (Patel *et al*., 2000). Growing water crises and need to produce more food per drop of water requires some efficient irrigation methods to enhance water productivity. Superiority of drip irrigation in terms of water saving and increased yield along with other benefits over conventional irrigation methods is proved by many research evidences (Pandey *et al.,* 2013).

Materials and Methods

An experiment was conducted at instructional farm, Junagadh Agricultural University, 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 was carried out with Alkaline $KMnO_4$ method by Subbaiah and Asija, 1956 (241.2 kg ha^{-1}), medium in available P (22.44 kg ha^{-1}) and available K (242.2 kg ha^{-1}). The available P and K were carried out with Olsen's method and Flame Photometric method by Olsen *et al*., 1954 and Jackson, 1974. 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^{-1}. 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 on growth and yield parameters: Data presented in table-1 and 2 indicated that different methods of irrigation significantly influenced growth and yield attributes 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), dry matter accumulation at 60, 90 and 120 DAS (16.40, 46.37 and 60.23 g), number of branches plant^{-1} at 60, 90 DAS and at harvest (9.53, 17.67 and 21.07), days to 50 % flowering (100 %), number of umbels plant^{-1} (22.58) and test weight (7.23 g) were recorded with drip irrigation at 1.0 PEF (I_3). Treatment I_2 (drip irrigation at 0.8 PEF) closely related to I_3 (drip irrigation at 1.0 PEF), However, drip irrigation at 0.8 PEF (I_2) was at par with surface method of irrigation (I_4) in pooled results. Conversely, drip irrigation at 0.6 PEF (I_1) registered significantly the lowest values of these growth and yield contributing parameters.

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

Treatments	Plant height (cm)				Dry matter accumulation (g)			Number of branches plant^{-1}			Days to 50 %
	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	At harvest	flowering
Irrigation levels (I)											
I_1- 0.6 PEF	67.43	92.22	108.82	121.42	11.72	35.88	52.92	7.33	13.83	17.64	83.87
I_2- 0.8 PEF	78.79	104.04	117.18	129.96	13.62	42.84	57.75	8.30	16.19	19.92	91.99
I_3- 1.0 PEF	92.01	113.68	127.86	140.58	16.40	46.37	60.23	9.53	17.67	21.07	99.86
I_4- 1.0 IW/CPE	72.38	97.96	113.86	122.79	12.58	36.91	55.27	7.83	14.81	19.13	86.06
S.Em.±	1.68	1.58	1.76	2.84	0.26	0.92	1.06	0.18	0.30	0.35	1.73
C.D. at 5 %	5.16	4.88	5.65	8.75	0.80	2.84	3.26	0.54	0.94	1.08	5.33
C.V. %	10.57	7.60	7.68	10.81	9.33	11.16	9.17	10.44	9.54	8.86	9.37
Nitrogen levels (N)											
N_0- Control	68.82	95.35	108.05	121.58	12.83	37.56	53.59	7.62	14.75	18.07	85.36
N_1- 60 kg N ha^{-1}	75.55	99.18	114.08	126.40	13.14	40.09	56.12	8.01	15.37	18.88	89.87
N_2- 90 kg N ha^{-1}	80.51	103.56	120.24	130.98	13.98	40.94	57.64	8.39	15.61	19.95	91.99
N_3- 120 kg N ha^{-1}	85.71	109.81	125.35	135.79	14.37	43.41	58.81	8.96	16.77	20.85	94.55
S.Em.±	1.35	1.37	1.35	2.50	0.24	0.58	0.78	0.13	0.30	0.30	0.99
C.D. at 5 %	3.83	3.90	3.83	7.10	0.67	1.65	2.22	0.36	0.84	0.84	2.81
C.V. %	8.50	6.59	5.65	9.51	8.55	7.03	6.76	7.48	9.26	7.46	5.35
Interaction I x N											
S.Em.±	2.69	2.74	2.70	5.00	0.47	1.16	1.56	0.25	0.59	0.59	1.98
C.D. at 5 %	7.66	7.80	7.67	14.21	1.35	3.30	4.43	0.72	1.68	1.68	5.62

Table-2: Seed and stover yield of fennel as influenced by different methods of irrigation and nitrogen levels (Pooled over two years)

Treatments	No. of umbels plant^{-1}	Test weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
Irrigation levels (I)					
I_1- 0.6 PEF	15.18	5.61	1129	2167	34.31
I_2- 0.8 PEF	18.03	6.63	1472	2500	37.03
I_3- 1.0 PEF	22.58	7.23	1833	2867	39.00
I_4- 1.0 IW/CPE	16.30	6.28	1222	2250	35.14
S.Em.±	0.35	0.15	32.62	49.26	0.95
C.D. at 5 %	1.07	0.46	100.50	151.77	2.91
C.V. %	9.47	11.37	11.30	9.87	12.74
Nitrogen levels (N)					
N_0- Control	16.64	5.78	968	2168	32.65
N_1- 60 kg N ha^{-1}	17.44	6.13	1339	2340	35.82
N_2- 90 kg N ha^{-1}	18.75	6.70	1574	2535	38.15
N_3- 120 kg N ha^{-1}	19.24	7.13	1777	2741	38.85
S.Em.±	0.33	0.11	20.00	28.66	0.70
C.D. at 5 %	0.93	0.32	56.86	81.51	1.99
C.V. %	8.87	8.51	6.93	5.74	9.44
Interaction I x N					
S.Em.±	0.65	0.22	39.99	57.33	1.40
C.D. at 5 %	1.85	NS	113.71	163.01	3.98

Levels of nitrogen did cause their significant impact on growth and yield attributes (Table 1&2). Application of nitrogen at the rate of 120 kg N ha^{-1} (N_1) significantly enhanced plant height at 60, 90, 120 DAS and at harvest (85.71, 109.81, 125.35 and 135.79 cm), dry matter accumulation at 60, 90 and 120 DAS (14.37, 43.41 and 58.81 g), number of branches plant^{-1} at 60, 90 DAS and at harvest (8.96, 16.77 and 20.85), days to 50 % flowering (94.55 %), number of umbels plant^{-1} (19.24) and test weight (7.13 g), except the application of 90 kg N ha^{-1}. While, significantly the lower growth and yield parameters were recorded under treatment control.

Table-3: Economics of different treatment combinations (Pooled over two years)

Treatment combinations	Seed yield (kg ha^{-1})	Gross realization (Rs. ha^{-1})	Total expenditure (Rs.ha^{-1})	Net realization (Rs. ha^{-1})
I_1N_0	1651	102714	72723	29991
I_1N_1	2123	131677	74985	56692
I_1N_2	2475	152996	75845	77151
I_1N_3	2784	171926	76707	95219
I_2N_0	1997	124064	72723	51341
I_2N_1	2811	173618	74985	98633
I_2N_2	3251	200242	75845	124397
I_2N_3	3719	228778	76707	152071
I_3N_0	2510	155441	72723	82718
I_3N_1	3514	216524	74985	141539
I_3N_2	4075	250444	75845	174599
I_3N_3	4567	280285	76707	203578
I_4N_0	1584	98708	41056	57652
I_4N_1	2263	140166	43318	96848
I_4N_2	2788	171883	44178	127705
I_4N_3	3143	193457	45040	148417

Effect on yield: A perusal of data furnished in table-2 revealed that seed yield and stalk yield of fennel were significantly influenced by various irrigation methods. Seed and stalk yields significantly influenced by levels of irrigation. Each increase in drip irrigation level significantly increased seed and stalk yields. Drip Irrigation at 1.0 PEF (I_3) recorded significantly the highest 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 (I_2), respectively. Significantly maximum harvest index (39 %) recorded under drip irrigation at 1.0 PEF (I_3). Drip irrigation at 0.6 PEF (I_1) produced significantly the lowest seed and stalk yields. Fennel seed yield increased with increase in nitrogen levels. 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}) as well as harvest index over control.

Effect on economics: Among the levels of drip irrigation 1.0 PEF along with 120 kg N ha^{-1} (I_3N_3) accrued maximum gross returns (‘ 280285 ha^{-1}) and net returns (‘ 203578 ha^{-1}) respectively, this treatment was closely followed I_3N_2 treatment combination (drip irrigation at 0.8 PEF with 90 kg N ha^{-1}) table-3.

The drip irrigation at 1.0 PEF had significant improvement in dry matter plant^{-1} at different growth stages of fennel seems to an account of better vegetative growth which is well reflected by increase in plant height and branches plant^{-1}. Similar funding were also reported by Patel *et al.,* 2000 in fennel and Rao *et al.,* 2010 in cumin. It is an established fact that the soil water deficiency inhibits leaf expansion and stem elongation in plants through its reduction of relative turgidity. Similar findings were also reported by Patel *et al.* (2007) in fennel. Application of 120 or 90 kg N ha^{-1} might have increased interception, absorption and utilization of radiant energy which in turn increased photosynthesis and there by plant height, dry matter accumulation and number of branches per plant and finally results in better growth. The enhanced growth with nitrogen was also reported by Patel *et al.* (2000), Nataraja *et al.* (2003) and Tuncturk (2011). In fact seed yield is the function of several yield components, which are depended on complementary interaction between vegetative and reproductive growth of crop. Similar results have also been reported by Lal *et al*. (2013) in fenugreek. 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).

As these growth and yield attributes evidently resulted in higher yields under higher nitrogen levels. Significantly increase in seed and stover 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 presents findings are in close agreement with the results obtained by Patel *et al.* (2000), Tank *et al.* (2006) and Ehsanipour *et al.* (2012). The total cost of production increased slightly with an increase in IW/CPE ratio for scheduling irrigation, because the irrigation charges were insignificant as compared with other expenses. The cost involved under this treatment was comparatively lower than its additional income, which led to more returns under this treatment. These results also substantiated by the findings of Bhunia *et al.* (2005) in fennel, Dutta and Chatarjee (2006) in fenugreek and Rao *et al.* (2010) in cumin.

On the basis of two years experimentation, it is concluded that drip irrigation at 1.0 PEF along with 120 kg N ha^{-1} was found to be the most superior treatment as it proved higher seed yield (‘ 2284 kg ha^{-1}), maximum net realization (‘ 101789 ha^{-1}) with maximum water use efficiency (3.22 kg ha^{-1} mm^{-1}) and higher consumptive use of water under the constraint of irrigation water, about 33.43 per cent water saving be obtained through irrigating crop at 0.6 PEF as compared to surface method of irrigation without reduction of *rabi* fennel yield.

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