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INFLUENCE OF DRIP IRRIGATION AND FERTILITY LEVELS ON GROWTH, YIELD AND WATER USE EFFICIENCY OF DRILLED *RABI* FENNEL (*FOENICULUM VULGARE* MILL.)

R.M. Solanki, M.S. Vasava and B.S. Gohil
Micro Irrigation Scheme, Department of Agronomy, College of Agriculture,
Junagadh Agricultural University, Junagadh-362001 (Gujarat, India)

Abstract: A field experiment was conducted at JAU, Junagadh, Gujarat to study the influence of drip irrigation and fertility levels on growth, yield and water use efficiency of drilled *rabi* fennel (*Foeniculum vulgare* Mill.) under south Saurashtra agro climatic region. Irrigation through drip at 0.8 PEF being on par a with 1.0 PEF recorded significantly higher plant height (125.5cm), number of branches (5.6), umbels plant^{-1} (16.0), seed (1442 kg ha^{-1}) and straw (2753 kg ha^{-1}) yields as well as gross and net return along with higher B:C ratio of the fennel on pooled basis. The maximum WUE of 2.20 was recorded at 0.6 PEF. Application of 120-45 NP kg ha^{-1} produced significantly higher growth and yield attributes, seed (1373 kg ha^{-1}) and straw yields (2689 kg ha^{-1}) as well as gross and net realization along with higher B:C ratio.
Keywords: Drilled fennel, Pan Evaporation Fraction (PEF), Water Use Efficiency (WUE), B:C ratio, net realization.

Introduction

Fennel (*Foeniculum vulgare* Mill) is mainly grown for its seeds which have pleasant fragrance, an aromatic taste and it is widely cultivated throughout the temperate and subtropical region of the world. In India, fennel is mainly grown in Gujarat and Rajasthan and to some extent in Utter Pradesh, Karnataka, Andhra Pradesh, Punjab, Madhya Pradesh, Bihar, Haryana and Jammu & Kashmir. Fennel crop occupied an area of about 91 thousand hectares with an annual production of 135 thousand tons during 2013-14. Gujarat occupied an area of 38000 hectares with an annual production of 55000 tons during 2013-14 (Anonymous, 2014). Generally fennel is cultivated as transplanted crop in Gujarat and Rajasthan. However, fennel is raised profitably as a winter (*rabi*) drill crop in Gujarat (Mehta *et al*., 1999). Area under drilled *rabi* fennel is increasing because of its short duration and more profitable spice than other *rabi* crops like wheat, cumin, coriander, fenugreek etc. However, productivity of drilled *rabi* fennel is low (1200 kg ha^{-1}) as compared to its potential yield of 2500 kg ha^{-1} (Patel *et al*., 2000). The reasons for low productivity may be poor management practices including irrigation and fertilizer application. Irrigation and fertilizers

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are costly and scare inputs for crop production. Availability of irrigation water is limited and therefore, it should be utilized most efficiently by adopting latest irrigation technologies. 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). Fertigation is considered as eco-friendly as it avoids the leaching of nutrients. Application of fertilizer in small quantities to the soil at any given time improves fertilizer use efficiency, helps to maintain nutritional balance and nutrient concentration at optimum level, saves energy and labour, provides opportunity to apply the nutrient at critical stages of crop growth and minimizes hazard of ground water. Information on water requirement by drilled *rabi* fennel and fertigation is lacking for Saurashtra region. Therefore, an experiment was undertaken to study the influence of drip irrigation and fertility levels on growth, yield and water use efficiency of drilled *rabi* fennel.

Materials and methods

A field experiment was conducted under Micro Irrigation Scheme, at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh-362 001(Gujarat) during *rabi* seasons of 2013-14 to 2015-16. The farm is located at about 21.5^0 N and 70.5^0 E longitudes with an average altitude of 60m above mean sea level under semi arid tropic having a little extreme of weather condition. The soil was medium black and clayey in texture, slightly alkaline (7.9), having organic carbon 0.55%, 41.0 kg ha^{-1} available P_2O_5 and 249.0 kg ha^{-1} K_2O. The experiment was laid out in Split Plot Design comprised of four irrigation levels *viz*., I_1= 0.6 PEF through drip, I_2= 0.8 PEF through drip, I_3= 1.0 PEF through drip and I_4= Irrigation at 0.8 IW/CPE ratio through surface method were allotted to main plot and three fertility levels (F_1=60-15 NP kg ha^{-1}, F_2= 90-30 NP kg ha^{-1} and F_3= 120-45 NP kg ha^{-1}) were assigned to sub plot and replicated thrice. Sowing of fennel (Var. Gujarat Fennel 12) was done at 45-75-45 cm (paired row). Full dose of phosphorus and 25% nitrogen were applied as basal at the time of sowing. Remaining 75% nitrogen was applied in three equal split at 20 days interval as per treatment through drip. Two common irrigations were given for proper germination of seeds and establishment of plants. The drip irrigation system was laid out at lateral spacing of 120cm with dripper spacing of 45cm and operated at pressure of 1.2 kg cm^{-2} with 4 LPH discharge rate. The scheduling of irrigation was done with 0.6, 0.8 and 1.0 PEF at alternate day irrigations were applied through drip and

in surface method; 50mm depth of irrigations were applied at 0.8 IW/CPE ratios. The data on growth and yield attributes and yields were recorded at maturity. Water use efficiency, gross and net realization as well as B: C ratio were worked out by using current market prices of produce and inputs used. Other agronomic package of practices was followed as per recommendations made for the crop in region.

Results and discussion

Effect of irrigation on growth, yield attributes and yield

A perusal of data furnished in Table-1and 2 indicated that different drip irrigation levels significantly affected growth characters, yield attributes and yields of fennel during individual years as well as in pooled results. Significantly maximum plant height (125.5 cm), numbers of branches (5.6), numbers of umbels (16.0), seed and straw yields of 1442 and 2753 kg ha^{-1}, respectively were recorded with irrigating the drilled *rabi* fennel through drip at 0.8 PEF (I_2) which remained at par with drip irrigation at 1.00 PEF (I_3) on pooled results basis. The magnitude of increases in seed and straw yields under 0.8 PEF over 0.6 PEF were to the tune of 13.1 and 23.8 per cent, correspondingly. Yield of a crop is the result of many physiological processes under which the crop is grown. It is mainly due to drip irrigation resulting in availability of higher soil moisture in the root zone throughout the crop period which resulted in higher relative leaf water content, growth parameters and dry matter production and subsequently in development of yield components and the yield. Jat *et al*. (2015) also reported that scheduling of irrigation through drip at 0.8 IW/CPE ratio with paired row planting was at par with 1.0 IW/CPE ratio recorded significantly higher seed and straw yields as well as growth and yield attributes. Similar results were also obtained by Godara *et al*. (2013) and Meena *et al.* (2016). Maximum net realization and B:C ratio were observed under 0.8 PEF whereas, higher water use efficiency and water saving were noted when crop was irrigated at 0.6 PEF (Table-3).

Effect of fertility levels on growth, yield attributes and yield

Three years individual and pooled results presented in Table-1and 2 revealed that growth parameters, yield attributes and yield of fennel were significantly influenced by different fertility levels during course of investigation and in pooled results. Significantly maximum plant height (122.8cm), number of branches (5.3) and number of umbels (15.2) were produced when drilled *rabi* fennel was fertilized with 120-45 NP kg ha^{-1}. Fertilizing the fennel with 120-45 NP kg ha^{-1} produced significantly higher seed and straw yields of 1373 and 2689 kg ha^{-1}, respectively. The respective per cent increases in seed and straw yields with

120-45 NP kg ha^{-1} over 60-15 NP kg ha^{-1} was to the tune of 13.5 and 12.9 per cent. This might be due to better nutritional environment in the root zone for the growth and development of the plant as N and P are considered as one of the major nutrients required for proper growth and development of plant. Besides this, nitrogen is main constituent of protoplasm, cell nucleus, amino acids, chlorophyll and many other metabolic processes. The increasing levels of N through drip restricted fertilizers to the wetted zone of the soil where the active roots are concentrated thus, leads to better utilization of nutrients, their uptake, enhanced vegetative growth and finally yield. The result confirms the findings of Godara *et al*. (2013), Koyani *et al*. (2015) and Meena *et al*. (2016). Numerically higher net realization, B:C ratio and water use efficiency were noted with the application of 120-45-00 NPK kg ha^{-1} (Table-3).

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Table: 1 Plant height, branches plant^{-1} and umbels plant^{-1} in fennel as influenced by drip irrigation and fertility levels

Treatment	Plant height (cm)				No. of branches plant^{-1}				No. of umbels plant^{-1}			
	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled
Drip irrigation levels (PEF)												
I_1 = 0.6	106.9	110.2	113.8	110.3	4.5	3.8	4.4	4.2	10.2	10.1	10.3	10.2
I_2= 0.8	126.9	121.2	128.6	125.5	6.1	5.3	5.3	5.6	15.5	15.6	16.9	16.0
I_3= 1.0	121.1	120.1	125.3	122.2	5.7	4.8	5.2	5.2	14.8	14.2	16.1	15.0
I_4- Surface	114.7	115.0	121.8	117.2	4.9	4.3	4.7	4.7	13.2	13.6	15.5	14.1
C.D. (P=0.05%)	8.2	5.4	7.8	3.6	0.9	0.6	0.4	0.3	2.4	1.4	2.2	1.0
Fertility levels (NP kg ha$^{-1)}$												
F_1 = 60-15	111.9	114.0	117.4	114.4	4.9	3.8	4.5	4.4	10.8	12.4	13.6	12.2
F_2= 90-30	118.2	116.3	123.1	119.2	5.4	4.8	5.0	5.1	14.1	13.3	14.7	14.0
F_3= 120-45	122.0	119.6	126.8	122.8	5.6	5.1	5.2	5.3	15.4	14.4	15.8	15.2
C.D. (P=0.05%)	4.1	3.4	5.8	2.5	0.5	0.4	0.3	0.2	1.2	0.8	1.5	2.1

Table: 2 Seed and straw yields of drilled *rabi* fennel as influenced by drip irrigation and fertility levels

Treatment	Seed yield (kg ha^{-1})				Straw yield (kg ha^{-1})			
	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled
Drip irrigation levels (PEF)								
I_1 = 0.6	1219	1130	1311	1220	2224	2175	2270	2223
I_2= 0.8	1443	1416	1468	1442	2695	2738	2827	2753
I_3= 1.0	1314	1306	1519	1380	2554	2518	3155	2742
I_4- Surface	1254	1082	1056	1131	2462	2340	2642	2482
C.D. (P=0.05%)	153.5	231.9	162.8	176.5	286.8	341.0	575.1	208.2
Fertility levels (NP kg ha$^{-1)}$								
F_1 = 60-15	1258	1161	1209	1210	2365	2253	2524	2381
F_2= 90-30	1277	1228	1386	1297	2473	2476	2792	2580
F_3= 120-45	1387	1312	1420	1373	2614	2599	2854	2689
C.D. (P=0.05%)	71.9	110.4	113.5	55.0	140.1	229.2	275.3	121.7

Table: 3 Economics, water use efficiency and water saving in drilled *rabi* fennel as influenced by drip irrigation and fertigation

Treatment	Seed yield (kg ha^{-1})	Gross return (Rs.ha^{-1})	Net return (Rs.ha^{-1})	B:C ratio	Water Use Efficiency (kg $ha^{-1}mm^{-1}$)	Water saving (%)
Drip irrigation levels (PEF)						
I_1 = 0.6	1220	81523	49601	1.55	2.20	30.6
I_2= 0.8	1442	96483	64061	1.98	2.04	12.0
I_3= 1.0	1380	92442	59520	1.80	1.79	3.5
I_4- Surface	1131	75997	42692	1.28	1.41	-
Fertility levels (NP kg $ha^{-1)}$						
F_1 = 60-15	1210	81031	49651	1.58	1.71	-
F_2= 90-30	1297	86885	54245	1.66	1.83	-
F_3= 120-45	1373	91934	58026	1.71	1.93	-