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Effect of drip irrigation and fertigation on yield and economics of fennel

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Abstract
A field experiment was conducted at Agronomy Farm, S.K.N. College of Agriculture, Jobner (Jaipur) during two consecutive *Rabi* seasons of the year 2015-16 and 2016-17 to study the effect of drip irrigation and fertigation on yield and economics of fennel on irrigated loamy sand soil of semi arid eastern plain zone of Rajasthan. The experiment comprised of ten treatments *i.e* surface irrigation with CF with 100 per cent RDF, drip irrigation with CF (50, 75 and 100 per cent RDF), drip fertigation with (50, 75 and 100) per cent RDN as well as RDF were replicated three times in randomized block design. The data revealed that seed, straw, biological yields, harvest index and economic parameters were significantly highest in drip fertigation with 75 per cent RDF compared to that of other treatments. Surface irrigation with conventional fertilization represented significantly lower magnitude of above mentioned parameters.

Keywords: Drip irrigation, fertigation, surface irrigation, conventional fertilization, fennel

Introduction
A spice is a dried seed, fruit, root, bark or vegetative substance used in flavouring, seasoning and imparting aroma in variety of food items and beverages. In India, wide varieties of spices are grown and many of them are native to the subcontinent and also known as "Home of Spices". Among the spices, seed spices are the group, which denotes all those annuals whose dried fruit or seeds are used as spices. The seed spices are aromatic vegetable products of tropical origin and are commonly used in pulverized form, primarily for seasoning or garnishing the foods and beverages. They are also used in preparation of various value added products *viz*., spice oils, oleoresins and spice powders. Fennel (*Foeniculum vulgare* Mill.) plant is stout, aromatic, annual herb (with potency of regeneration) belongs to family Apiaceae. It is mainly cultivated in Gujarat, Rajasthan and Uttar Pradesh. It is used as condiment and culinary spice. The seeds contain about 9.5 per cent protein, 10.0 per cent fat, 42.3 per cent carbohydrates, 18.5 per cent fiber and 13.4 per cent minerals. Reduced agricultural productivity and water use efficiency are mainly due to conventional method of irrigation (flooding) and poor adoption of scientific water management practices. Therefore, drip method of irrigation is most suited for semi-arid and arid areas where water is scarce and where low water consuming and high value crops can be grown. Drip method of irrigation helps to reduce the over exploitation of ground water that partly occurs because of inefficient use of water under surface method of irrigation (Meena *et al*., 2017) [1]. Fertigation is one important precision farming technique which can give better nutrient use efficiency as compared to surface irrigation method. Application of nutrients untimely, following inappropriate method of application leads to severe loss of nutrients by leaching and fixation (Harisha *et al*., 2017a) [2].

Materials and method
An experiment was conducted on plot No. B-1 at Agronomy Farm, S.K.N. College of Agriculture, Jobner, District Jaipur (Rajasthan). Geographically, Jobner is located 45 km west of Jaipur at 26^0 05' North latitute, 75^0 28' East longitude and at an altitude of 427 metres above mean sea level. The place falls in agroclimatic zone III A (Semi-arid Eastern Plain Zone) of Rajasthan. The climate of this region is a typically semi-arid, characterized by extremes of temperature during both summer and winter. During summer, the temperature may go as high as 48 ^{0}C while in winter, it may fall as low as -1.0 ^{0}C. The average annual rainfall of this tract ranges between 300-400 mm,

most of which is contributed by the South-west monsoon during the months of July and August. A total of 41.8 mm rainfall was received during the crop season and pan evaporation was 610.4 mm during crop season. The soil of the experimental field was loamy sand in texture, alkaline in reaction, poor in organic carbon with low available nitrogen and phosphorus and medium in potassium content, field capacity of soil is 10.85 per cent and PWP is 4.32 per cent. The experiment consisted of ten treatments (Surface irrigation with CF (100 per cent RDF), drip irrigation with CF (50, 75 and 100 percent RDF), drip fertigation with (50, 75 and 100 percent RDN) and drip fertigation with (50, 75 and 100 percent RDF). The experiment was laid out in Randomized Block Design with three replications. The variety RF- 125 was used. Plants are erect with 101.60-120.40 cm height, compact umbels and long bold seed. It matures in 120-130 days. The field was ploughed after pre sowing irrigation by tractor drawn disc plough and disc harrow followed by planking. The seed beds of 6 m x 3 m size were prepared as per layout plan. The crop was planted at a row spacing of 50 cm. The plant space mainted at 20 cm within the row. The recommended dose of fertilizer for fennel in the semi-arid eastern plain zone is 90:40:0 kg/ha. In conventional method of fertilizer application (T_1 to T_4) the entire quantity of phosphorus was applied as basal through single super phosphate and nitrogen through urea in three equal splits as top dressing. In treatment of RDN (T_5, T_6 and T_7) the phosphorus through single super phosphate was applied as basal and nitrogen through urea as drip fertigation. In drip fertigation treatments of RDF (T_8, T_9 and T_{10}) the nitrogen and phosphorus were applied through urea and urea phosphate as drip fertigation in five splits at an interval of 20 days. The sulphur supplied with single super phosphate in some treatments was adjusted with the application of elemental sulphur in rest of the treatments so that sulphur applied will remain same in all the treatments. The measured quantity of irrigation water was supplied by drip irrigation in drip irrigation treatments and by check basin in surface irrigation at 0.8 IW/CPE ratio determined by cumulative pan evaporation. The required pressure and discharge in drip system was maintained with overflow valve with the supply source. The irrigation was given an alternate day in drip irrigation and at an interval of 10-20 days in surface irrigation. In order to minimize weed competition, two weeding and hoeing was done manually at 25 and 45 days after sowing. The weeds were pulled out manually in all plots. To maintain uniform plant stand at an intra row spacing of 20 cm, extra plants were thinned out. Data on growth, yield attributes and yield were recorded at different intervals and crop maturity. The economic parameters (gross returns, net returns and benefit: cost ratio) were worked out on the basis of prevailing market prices of inputs and outputs. The experimental data recorded for growth, yield and other characters were statistically analysed by fisher's analysis of variance technique (Fisher, 1950) [3]. The treatments means were compared at 5% level of significance.

Results and discussion

Yield

Surface irrigation with conventional fertilization recorded significantly lower seed, straw and biological yields (1677, 4206 and 5883 kg/ha) of fennel over drip irrigation with conventional fertilization as well as fertigation except drip irrigation with conventional fertilization (50 per cent RDF) (Table 1.). The decrease in fennel seed yield with surface irrigation with conventional fertilization was mainly attributed by lesser and inconsistent availability of soil moisture and nutrients which resulted in the poorer crop growth, yield components and ultimately reflected on the seed and straw yields of fennel. Similar results were reported by Krishnasamy *et al*. (2012) [4] and Pawar *et al*. (2013) [5].

The analysed pooled data revealed that yield of fennel was significantly improved with drip fertigation with 75 per cent RDF. However, it remained statistically at par with drip fertigation of 100 per cent RDF as well as 100 per cent RDN. Drip fertigation at 75 per cent RDF increased seed (2516 kg/ha) by 50.02 per cent, straw (7098 kg/ha) by 68.76 per cent and biological yields (9613 kg/ha) by 63.40 per cent over surface irrigation with conventional fertilization (Table 1.). The yield increase in drip irrigation is due to frequent water application through drip irrigation results in favourable micro climate and keeps constantly soil moisture near to field capacity which helps in increasing the yield. The placement of nutrients just near the base of plant through fertigation became quite useful as there was no leaching loss and the optimum soil moisture which was prevailing within crop root zone resulted in a better utilization of applied nutrients.

Reproduction and seed development are seriously affected by moisture and nutrients stress in fennel. The most critical period with respect to water and nutrients stress begins with the appearance of pollen mother cell, which decides the number of seed setting in umbels. The damage occurred to reproductive stage due to water and nutrients deficiency may not recover with supply of water and nutrients at another stage of crop. 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 findings were also observed by Jat *et al*. (2011) [6], Sharma and Kaushal (2015) [7] and Singh *et al.* (2018) [8] in Pigeon pea. Results of present study are close related with the findings of Magare *et al.* (2018) [9] who observed that seed cotton yield was recorded significantly highest under 100 per cent RDF through drip fertigation over 100 per cent RDF through soil fertilization.

Economics

It is evident from data (Table 2.) that drip irrigation with conventional fertilization as well as fertigation at different fertility levels enhanced the net returns and B:C ratio as compared to surface irrigation with conventional fertilization. The drip fertigation at 75 per cent RDF, exhibited significantly highest net returns of fennel, whereas it remained equally effective with drip fertigation at 100 per cent RDF and 100 per cent RDN. The net returns received with drip fertigation with 75 per cent RDF (`154162/ha) was higher by ` 55959/ha over surface irrigation with conventional fertilization. This represented an increase of 56.98 per cent over surface irrigation with conventional fertilization (Table 2.). The higher B:C ratio obtained under the drip fertigation due to higher yield produced under these system with minimum losses of water. Soil nutrients were efficiently utilized by the plants in drip fertigation. The total cost of production increased in drip irrigation and fertigation due to additional cost of drip system and high market cost of water soluble fertilizers. The cost involved under this treatment was comparatively lower than its additional income, which led to more returns under this treatment. Pawar *et al*. (2013) [5] also reported superiority of drip fertigation over conventional fertilization in terms of productivity and economics of sugarcane. Ankush and Singh (2017) [10] also studied the

effect of drip fertigation on economics of tomato and obtained maximum net return (`220115.43/ha) and B: C ratio (2.40) with 75 per cent PE through drip irrigation and application of 75 per cent RDF through drip fertigation.

Table 1: Effect of drip irrigation and fertigation on seed, straw, biological yields and harvest index of fennel

Treatments	Seed yield (kg/ha)			Straw yield (kg/ha)			Biological yield (kg/ha)			Harvest index (%)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Surface irrigation with CF (100% RDF)	1720	1634	1677	4391	4021	4206	6111	5655	5883	28.15	28.89	28.52
Drip irrigation with CF (50%RDF)	1858	1765	1811	4873	4503	4688	6731	6268	6499	27.60	28.16	27.88
Drip irrigation with CF (75% RDF)	2116	2015	2065	5666	5296	5481	7782	7311	7546	27.19	27.56	27.37
Drip irrigation with CF (100% RDF)	2202	2073	2137	5931	5561	5746	8133	7634	7883	27.07	27.15	27.11
Drip fertigation with 50% RDN	2050	1945	1997	5455	5081	5268	7505	7026	7265	27.31	27.68	27.50
Drip fertigation with 75% RDN	2327	2222	2275	6354	5984	6169	8681	8206	8444	26.81	27.08	26.94
Drip fertigation with 100% RDN	2460	2320	2390	6877	6337	6607	9337	8657	8997	26.69	27.25	26.97
Drip fertigation with 50% RDF	2274	2162	2218	6242	5932	6087	8516	8094	8305	26.99	27.20	27.10
Drip fertigation with 75% RDF	2580	2451	2516	7306	6889	7098	9886	9340	9613	26.10	26.11	26.10
Drip fertigation with 100% RDF	2700	2512	2606	7736	7266	7501	10436	9778	10107	25.63	25.18	25.40
SEm±	88	83	60	239	255	175	326	306	231	1.10	1.12	0.79
CD (P=0.05)	263	249	173	715	765	521	978	916	693	NS	NS	NS

Table 2: Effect of drip irrigation and fertigation on net returns and B: C ratio of fennel

Treatments	Net returns (`/ha)			B:C ratio		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Surface irrigation with CF (100% RDF)	102073	94333	98203	2.94	2.79	2.86
Drip irrigation with CF (50%RDF)	99714	91355	95534	2.48	2.35	2.42
Drip irrigation with CF (75% RDF)	122570	113516	118043	2.81	2.67	2.74
Drip irrigation with CF (100% RDF)	129945	118371	124158	2.91	2.74	2.82
Drip fertigation with 50% RDN	116862	107385	112124	2.73	2.59	2.66
Drip fertigation with 75% RDN	141539	132093	136816	3.08	2.95	3.01
Drip fertigation with 100% RDN	153201	140601	146901	3.25	3.06	3.15
Drip fertigation with 50% RDF	134294	124167	129231	2.91	2.76	2.84
Drip fertigation with 75% RDF	159967	148357	154162	3.21	3.05	3.13
Drip fertigation with 100% RDF	168972	152016	160494	3.28	3.05	3.17
SEm±	5190	4756	3520	0.09	0.08	0.06
CD (P=0.05)	15550	14251	10095	0.21	0.20	0.18

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