Journal of Spices and Aromatic Crops
Vol. 32 (2): 194-201 (2023)
10.25081/josac.2023.v32.i2.8881

Indian Society for Spices

Influence of irrigation and nitrogen levels on yield attributes, yield and water use efficiency in dill (*Anethum graveolens* L.) cultivation

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Received 12 March 2023; Revised 05 June 2023; Accepted 08 January 2024

Abstract

The field experiments were conducted during three consecutive *Rabi* seasons during 2016-19 at Agricultural Research Station, SKRAU, Bikaner to study the influence of irrigation and nitrogen levels to growth, yield attributes, yield and water use efficiency of dill (*Anethum graveolens* L.) under drip irrigation system. The experiment consisted of sixteen treatment combinations of four irrigation levels (ETc- 0.4, ETc- 0.6, ETc- 0.8 & ETc- 1.0), & four nitrogen levels (control, 120% RDN in 4 splits, 100% RDN in 4 splits and 80% RDN in 4 splits). The treatments were laid out in a split plot design with three replications. Results revealed that irrigation at ETc 1.0 with application of nitrogen at 120% of RDN in four splits recorded significantly higher crop yield as compared to the remaining treatments. The water use efficiency decreased with increased irrigation and nitrogen levels.

Keywords: Dill, drip irrigation, nitrogen, WUE, yield

Introduction

India is the world's largest spice producer, exporter, and consumer and India exports spices and spice products to more than 180 countries in the world. In India, about 10.5 million tons of spices are produced annually. Dill (*Anethum graveolens* L.) is native to south-west Asia or south-east Europe, and has been cultivated since ancient times (Bailer *et al*., 2001). It's an annual and sometimes biennial spice crop belonging to family *Apiaceae.* Dill is commonly known as ‘‘sowa”. Young aromatic foliage is used as green vegetable for aroma in culinary preparations. Dill seeds are used for flavouring and seasoning due to their warming and pleasant aromatic flavor. Seeds are also used as an anti-spasmodic, anti-flatulent, carminative, anti-inflammatory, anti-rheumatic and diuretic in pharmacological industry. Dill crop is cultivated extensively in many countries of Europe, Asia and Americas as an aromatic and medicinal herb (Singh *et al*., 2005). Leading states of dill cultivation in India are Punjab, Uttar Pradesh, Gujarat, Maharashtra, Assam and West Bengal. Essential oil contains carvone (62.48%), apiole (19.51%) and limonene (14. 61%) at fruiting stage (Hussein Said Al Ahl *et al*., 2015). *Anethum graveolens* may be considered as an abundant source of natural antioxidants, especially recommended for healthy reformulation of food products to protect human health (Paven *et al*., 2018). Endogenous antioxidant defense mechanisms may be insufficient and hence dietary intake of antioxidant compounds is essential (Yakubu *et al*., 2013). The natural antioxidants have been associated with reduced risk of cancer, cardiovascular disease and diabetes (Ani *et al*., 2006). The liver is associated with many important life functions; it has a great capacity to detoxicate toxic substances and synthesize useful principles (Si-Tayeb *et al*., 2010). The extract of *Anethum graveolens* could protect the liver against high fat diet-induced oxidative damage in rats (Bahramikia *et al*., 2009). In western Rajasthan especially in Bikaner and Jaisalmer districts, soil fertility is very poor due to low organic matter and sandy soils. Macropore spaces are more in this type of soil, leading to nutrient loss due to leaching. Hence, fertility management of soil is one of the key factors influencing the growth and yield of plants. Therefore, judicious and proper use of nutrients source is much essential for obtaining higher yield with good quality of produce and it also maintains soil health for longer period (Patil *et al*., 2016). The aim of this study was to investigate the effect of different nitrogen levels with drip irrigation on growth, yield, quality and water use efficiency of *Anethum graveolens* L. plants.

Materials and methods

The field experiments were conducted during three consecutive *Rabi* seasons from 2016-19 at Agricultural Research Station, SKRAU, Bikaner to study the influence of different drip irrigation and nitrogen levels on growth, yield attributes, yield and water use efficiency in dill cultivation. The treatments comprised of four irrigation levels (ETc - 0.4, ETc - 0.6, ETc - 0.8, ETc – 1.0) and four nitrogen doses (control, 120% of recommended dose of nitrogen (RDN), 100% RDN, 80% RDN). These sixteen treatment combinations were laid out in split plot design with three replications. The soil of the experimental field was sandy loam in texture with medium in fertility status, having OC 0.25%, and 111, 27.5, 220 kg/ha available NPK, respectively and alkaline in reaction (pH 8.28) with EC 0.09 ds/m of 2:1 soil water suspension. The recommended dose of P_2O_5: K_2O (40:20) was applied just before sowing using single super phosphate and muriate of potash and nitrogen was applied as per treatment using venturi drip system through urea. The irrigation was applied as per levels of irrigation which was supplied on the basis of daily climatic data. The maximum and minimum temperature, maximum and minimum relative humidity, wind speed, and sunshine hours were used to determine evapotranspiration (ET_0) by using FAO 56

Penman Monteith's method. Evapotranspiration (ET_0) and Crop coefficient (Kc) were used to calculate the crop evapotranspiration (ETc).

The following formula was used:

$$ETc = ET_0 \times Kc$$

Where:

ET_c =Crop evapotranspiration (mm day^{-1})

ET_0= Reference evapotranspiration (mm day^{-1})

Kc = Crop coefficient

The requirement of daily irrigation water for dill was estimated as:

$$IR = ETo \times Kc - Re$$

Where:

IR= Net depth of irrigation (mm day^{-1})

ETo= Reference evapotranspiration (mm day^{-1})

Kc = Crop coefficient

Re= Effective rainfall (mm day^{-1})

The net volume of water required by the plant can be calculated as:

$$V = IR \times A$$

Where:

V= Net volume of water required by a plant (L day^{-1} $plant^{-1}$)

A= Area under each plant (m^2)

Observations were recorded manually from each plot, from each replication separately as per standard (ten plants from each plot). The seed and straw yield were recorded from net plot area of every plot. The experimental data were statistically analyzed using the method described by Panse and Sukhatme (1985).

Results and discussion

Effect of irrigation levels on crop yield

Irrigation applied at 1.0 ETc recorded maximum yield *viz.* seed, straw and biological yields and were significantly higher over irrigation applied at 0.4, 0.6 and 0.8 ETc levels (Table 1).

Table 1. Effect of irrigation and nitrogen levels on yield, yield attributes and economics of dill crop (three years pooled data)

Treatment	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Test weight (g)	Harvest index (%)	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C Ratio
A. Irrigation levels (Main plot)								
ETc- 0.4	883	1675	2558	4.02	34.25	59381	26589	1.64
ETc- 0.6	1052	2037	3089	4.07	33.49	71067	38275	1.96
ETc- 0.8	1171	2259	3430	4.13	33.62	79106	46314	2.19
ETc- 1.0	1255	2406	3661	4.19	33.70	84713	51921	2.34
S Em ±	35	66	66	0.08	0.96	2200	2200	0.06
C D at 5%	103	197	195	NS	NS	6537	6537	0.18
B. Fertigation (Sub plot)								
Control	797	1617	2414	4.03	32.62	54093	21826	1.52
120% RDN in 4 splits	1247	2386	3633	4.17	33.90	84076	50969	2.31
100% RDN in 4 splits	1202	2277	3479	4.12	34.19	81009	48042	2.23
80% RDN in 4 splits	1115	2097	3212	4.09	34.35	75089	42262	2.08
S Em ±	32	90	100	0.06	0.94	2095	2095	0.06
C D at 5%	91	253	281	NS	NS	5907	5907	0.16

In arid condition and sandy loam drip irrigation on the basis of climatologically approach hold great promise for minimizing loss of irrigation water and improving its use efficiency and ultimately productivity (Bhunia *et al.,* 2015). Water applied at ETc1.0 recorded increased seed yield by 43.59, 18.11and 6.48 per cent over water applied at ETc 0.4, 0.6 and 0.8, respectively.

Effect of nitrogen levels on crop yield:

Application of nitrogen @ 120% of RDN in four splits recorded the highest seed, straw and biological yield and was on par with 100% and 80% RDN with four splits but was significantly higher over control. Fertigation is a method of applying nutrients directly into the root zone of a crop, which improves fertilizer-use efficiency when compared to traditional fertilizer application methods (Hebbar *et al.,* 2004). Test weight and harvest index were not influenced by irrigation levels. The irrigation at ETc1.0 recorded the highest test weight while the irrigation at 0.4 ETc recorded the highest harvest index (Table 1). Application of 120% RDN significantly increased water use efficiency of the crop over control, but remained at par with 100% and 80% RDN which corroborated the finding of Naruka *et al.* (2012).

Effect of irrigation and nitrogen levels on WUE:

Water use efficiency was recorded maximum in irrigation provided at 0.4 ETc levels and was lowest at 1.0 ETc level. Water use efficiency increased significantly under reduced the irrigation levels and was highest in ETc 0 (Job *et al.,* 2018). In case of nitrogen application, it was maximum with application of 120% RDN.

Effect of irrigation and nitrogen levels on economics:

Data presented in table 1 revealed that irrigation level ETc 1.0 resulted in maximum monetary returns as compared to ETc 0.4 and ETc 0.6 but was on par with ETc 0.8. ETc 1.0 recorded the maximum net returns (₹51921) and B: C ratio (2.34). Application of 120% RDN resulted in maximum net returns and B: C ratio (2.31) as compared to control but it was on par with 100% and 80 % of RDN. Kadbe *et al.* (2012) also reported similar results.

Interaction effects

Data presented in table 2 showed that increasing quantity of nitrogen with increased levels of irrigation increased seed, straw and biological yield of dill in general and it also increased the economic benefit as reported by Meena and Man (2017). Application of nitrogen (120 kg ha^{-1}) in four splits with ETc 0.8 level recorded the maximum yield and economic returns. But WUE increased with decreasing levels of irrigation and increasing nitrogen levels.

In conclusion, increasing nitrogen levels with irrigation levels improved plant physiology and ultimately lead to increased biomass and yield of dill. The water use efficiency increased with decreasing levels of irrigation and increasing levels of nitrogen. The maximum was recorded with irrigation applied at ETc 0.4 level. 100 % RDN recorded better yield with irrigation applied at ETc 1.0.

Table 2. Interaction effect of irrigation and nitrogen levels on yield, yield attributes, economics and WUE of dill crop (three years pooled data)

Treatment	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Test weight (g)	Harvest index (%)	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio	WUE (kg ha^{-1} mm^{-1})
ETc- 0.4 + Control	730	1472	2202	3.98	32.82	49339	17073	1.39	5.50
ETc- 0.4 + 120% RDN in 4 splits	955	1876	2831	4.06	33.73	64281	31175	1.76	7.21
ETc- 0.4 + 100% RDN in 4 splits	936	1716	2651	4.04	35.02	62794	29828	1.73	7.05
ETc- 0.4 + 80% RDN in 4 splits	911	1638	2549	4.01	35.42	61107	28280	1.69	6.83
ETc- 0.6 + Control	741	1523	2264	4.02	32.34	50380	18113	1.42	3.60
ETc- 0.6+ 120% RDN in 4 splits	1247	2408	3654	4.14	33.66	84061	50954	2.31	6.18
ETc- 0.6 + 100% RDN in 4 splits	1119	2177	3296	4.09	33.49	75623	42656	2.08	5.50
ETc- 0.6 + 80% RDN in 4 splits	1100	2039	3140	4.04	34.46	74203	41377	2.05	5.37
ETc- 0.8 + Control	837	1701	2538	4.06	32.65	56972	24706	1.60	3.00
ETc- 0.8+ 120% RDN in 4 splits	1336	2557	3893	4.17	33.85	90170	57063	2.47	4.94
ETc- 0.8 + 100% RDN in 4 splits	1329	2577	3906	4.15	33.67	89535	56568	2.47	4.98
ETc- 0.8 + 80% RDN in 4 splits	1182	2202	3385	4.14	34.31	79746	46919	2.21	4.34
ETc- 1.0 + Control	879	1772	2651	4.06	32.64	59679	27412	1.68	2.54
ETc- 1.0+ 120% RDN in 4 splits	1450	2703	4153	4.31	34.36	97792	64685	2.68	4.27
ETc-1.0 + 100% RDN in 4 splits	1426	2637	4063	4.21	34.57	96082	63115	2.65	4.21
ETc- 1.0+ 80% RDN in 4 splits	1265	2510	3775	4.19	33.21	85298	52471	2.36	3.80
S Em ±	64	180	199	0.12	1.88	4191	4191	0.12	0.27
C D at 5%	181	507	562	NS	NS	11715	11715	0.33	0.77

Acknowledgement

We thank *RKVY Project*, Agricultural Research Station, S K Rajasthan Agricultural University, Bikaner (Rajasthan) for providing necessary facilities for the experiments.

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