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Original Research Article

Enhancing Yield, Profitability and Water Use Efficiency through Drip-Fertigation in Cumin (*Cuminum cyminum* L.)

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Abstract: An experiment was conducted during *rabi* seasons of 2013-14 and 2014-15 on clayey soil at Krishi Vigyan Kendra Farm, Junagadh Agricultural University, Porbandar (Gujarat) to assess the yield, profitability and water use efficiency of cumin (*Cuminum cyminum* L.) under different levels of drip irrigation and fertigation. The experiment was laid out on split plot design comprising of three drip irrigation levels (irrigation at 0.6, 0.8 and 1.0 PEF) and four fertigation levels (50, 75, 100 and 125% RDF in five equal splits) with three replications. The results revealed that drip irrigation at 0.8 PEF registered significantly the highest plant height (31.6 cm), number of branches plant^{-1} (7.98), number of umbels plant^{-1} (23.1), number of umbellates umbel^{-1} (8.3), number of seeds umbellates^{-1} (21.5), 100-seed weight (4.64 g), seed yield (878 kg ha^{-1}) and stover yield (1495 kg ha^{-1}) of cumin on pooled basis. Fertigation with 125% RDF recorded significantly higher growth and yield attributes and ultimately higher seed and stover yield of 919 kg ha^{-1} and 1537 kg ha^{-1}, respectively. The maximum water use efficiency was recorded in irrigation at 0.8 PEF (2.31 kg ha^{-1} mm^{-1}) and fertigation with 125% RDF (2.45 kg ha^{-1} mm^{-1}). Further the treatment combination of drip irrigation at 0.8 PEF and fertigation with 125% RDF emerged out to be the best treatment combination with the highest seed yield (1026 kg ha^{-1}), gross return (Rs. 113035 ha^{-1}), net return (Rs. 74504 ha^{-1}) and BCR (2.94).

Keywords: *Cumin, drip irrigation, fertigation, RDF, BC ratio*.

INTRODUCTION

Cumin (*Cuminum cyminum* L.) is an important seed spice crop of arid and semi-arid regions of India. Gujarat alone contribute about 44% of area and 61% of national production of 3.74 lakh ha 2.83 lakh tonnes, respectively (Anon., 2015). Availability of water, an essential requirement for growing the crops is becoming most precious natural resource on this planet so water management is the need of an hour wherein every drop is to be put to its most efficient use. Most of the seed spices crops are grown in arid and semi-arid regions hence, the efficient utilization of water for these crops is one of the biggest challenges for the seed spices producers. Drip irrigation system has proved to be of utmost importance from water and nutritional management point of view in various crops ranging from perennial plantations to annuals and seasonal vegetable crops. Drip irrigation system is not only a successful water management solution in terms of saving the quantity but enhances the availability of moisture directly to root zone of plants (Maheria *et al.*, 2012).

Applying plant nutrients by dissolving them in irrigation water (termed as fertigation) particularly with the drip system is a most efficient way of nutrient application than broadcasting or furrow application which reduces fertilizer use efficiency. Thus the distribution of chemicals in the irrigation water will likely place these chemicals in the desired location, the root zone. This reduces water and fertilizer application (Clark *et al.*, 1991). Cumin needs optimum levels of soil moisture not only during its initial establishment and growth but also on other critical stages of flowering and seed ripening. Hence, an attempt was made to study the effect of drip irrigation scheduling and fertigation levels on growth and yield of cumin.

Materials and Methods

An experiment was conducted at Krishi Vigyan Kendra, Junagadh Agricultural University, Porbandar (Gujarat) during *rabi* season of 2013-14 and 2014-15 to study the effect of drip irrigation and. The soil of the experimental field was clay loam in texture

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with slightly alkaline pH (7.77) having 0.27% organic carbon and low in available N (198.6 kg ha^{-1}), medium in available P_2O_5 (52.81 kg ha^{-1}) and high in available K_2O (351.9 kg ha^{-1}). The experiment comprising three drip irrigation scheduling levels *viz.*, drip irrigation at 0.6, 0.8 and 1.0 PEF as main plot treatments and four fertigation levels *viz.*, 50, 75, 100 and 125% RDF (RDF: 30-15-0 N-P_2O_5-K_2O kg ha^{-1}) was laid out on split plot design with three replications. The cumin variety GC-4 was sown in the experimental field in 1st week of December, using seed rate of 16 kg ha^{-1} at 30 cm row spacing. Thinning was done at 20-22 DAS to maintain optimum plant population in each plot. All the other package of practices including appropriate plant protection measures were followed as per the recommendations throughout the cropping season.

Drip irrigation system in the experimental field was installed with PVC main and sub main lines having 75 and 50 mm diameter, respectively. LDPE lateral lines having 16 mm diameter x 2.5 kg cm^{-2} spaced at 60 cm with 4 LPH drippers were spaced at 37.5 cm. Lateral cocks of 16 mm at the starting of the lateral lines were installed to control irrigation and fertilizer application as per the treatments. Irrigation was given every three days interval as per the treatment. Fertilizer tank with ventury injector of 75 mm was used for fertilizer application. Fertigation was applied through water soluble fertilizers (WSF) like urea (46% N) and phosphoric acid (52% P_2O_5) in five equal splits at 15 days interval as per the treatment. A common irrigation was given just after sowing through flood method to facilitate uniform germination of the crop. The required quantity of water was applied through drip irrigation at three days interval on the basis of evaporation. Daily evaporation was noted with the help of Sunken Screen Open Pan Evaporimeter installed in the plot. The time of drip system operation and quantity of irrigation water required for varying drip irrigation treatments was calculated as under:

$$T_o = \frac{\text{PEF level} \times \text{CPE} \times \text{Dripper spacing (m)} \times \text{Lateral spacing (m)} \times 60}{\text{Dripper discharge (L hr}^{-1})}$$

Where,
PEF = Pan evaporation fraction
CPE = Cumulative pan evaporation (mm)
Dripper spacing = 0.6 m
Lateral spacing = 0.375 cm
Dripper discharge = 4 L hr^{-1}
Water applied (mm) = PEF x CPE

RESULTS AND DISCUSSION

Growth and Yield Attributes

The two-year pooled results (Table 1) revealed that drip irrigation at 0.8 PEF had significant effect on growth and yield attributes of cumin over other drip irrigation levels. All the growth parameters *viz.*, plant height at harvest (31.6 cm), numbers of branches $plant^{-1}$ at harvest (7.98), number of umbels $plant^{-1}$ (23.1), number of umbellates $umbel^{-1}$ (8.3), number of seeds $umbellate^{-1}$ (21.5) and test weight (4.64 g) were significantly increases by 0.8 PEF level of drip irrigation. However it remained at par with drip irrigation at 1.0 PEF level except number of branches $plant^{-1}$ and number of umbellates $umbel^{-1}$. This may be due to sufficient soil moisture is maintained with drip irrigation which leads to greater development of green tissue area and results in a higher photosynthetic assimilation. The plants are able to maintain higher water potential with increasing FPE ratio under drip irrigation which improves physiological and biochemical activities. These facts clearly suggested the importance of adequate supply of water for the optimum metabolism in the plants for better growth and development. The results are in agreement with that of Jangir and Singh (1996). Application of 125% RDF through fertigation significantly increased all the growth and yield attributes over other levels of fertigation which is attributed to the restriction of fertilizer in wetter zone of soil where active roots are concentrated. These results are in confirmation with those reported by Meena (2015).

Yields and Water Use Efficiency

Yields and water use efficiency was significantly influenced by different drip irrigation schedules and fertigation levels. The pooled data (Table 2) indicated that drip irrigation at 0.8 PEF recorded significantly the highest seed and stover yield of 878 and 1495 kg ha^{-1}, respectively with higher water use efficiency (2.31 kg ha^{-1} mm^{-1}). However, the seed yield was at par with drip irrigation at 1.0 PEF level. The magnitude of increase in seed yield under drip irrigation level 0.8 FPE was 41.1 per cent over drip irrigation level 0.6 PEF, while the extent of increase in water use efficiency was 32.0% over drip irrigation at 1.0 PEF level. This might be due to water is applied through drip 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.

Table 1.Effect of drip irrigation and fertigation on growth and yield attributes of cumin

Treatments	Plant height (cm)	Number of branches plant^{-1}	Number of umbels plant^{-1}	Number of umbellates umbel^{-1}	Number of seeds umbellate^{-1}	100-seed weight (g)
Drip irrigation (I)						
I_1- 0.6 PEF	23.6	5.49	17.9	5.7	16.0	3.81
I_2- 0.8 PEF	31.6	7.98	23.1	8.3	21.5	4.64
I_3- 1.0 PEF	30.8	6.18	22.3	7.1	20.3	4.60
S.Em.±	0.8	0.23	0.5	0.3	0.5	0.08
C.D. at 5%	2.6	0.77	1.7	0.9	1.6	0.28
C.V.%	13.8	15.40	12.1	17.0	12.7	9.54
Fertigation (F)						
F_1- 50% RDF	24.8	5.16	19.0	5.3	16.9	3.59
F_2- 75% RDF	27.3	6.11	20.3	6.5	18.4	4.16
F_3- 100% RDF	29.8	6.98	21.7	7.6	20.0	4.69
F_4- 125% RDF	32.8	7.97	23.3	8.8	21.8	4.96
S.Em.±	0.6	0.23	0.5	0.3	0.4	0.12
C.D. at 5%	1.8	0.67	1.5	0.9	1.1	0.34
C.V.%	9.3	12.88	10.9	14.7	11.3	7.86
I x F						
S.Em.±	1.1	0.41	0.9	0.5	0.7	0.21
C.D. at 5%	3.1	1.16	2.7	1.5	2.0	NS

The results are in agreement with Paul *et al.* (2013). Further, decreasing trend in yield with drip irrigation at 1.0 PEF level might be due to conducive effect of wet rhizosphere on maintenance of wet surface for longer period and consequently had led to higher losses through evaporation. Kunapara (2013) reported that higher yield attributes and yield can be obtained with drip irrigation at 0.8 IW:CPE ratio over 1.0 IW:CPE in cumin and additional water had no advantages as cumin is highly sensitive to excess water.

Significantly higher seed yield (919 kg ha^{-1}) and stover yield (1537 kg ha^{-1}) with higher water use efficiency (2.45 kg ha^{-1} mm^{-1}) were registered under application of 125% RDF through fertigation over other fertigation levels. The increase in seed and stover yield with 125% RDF through fertigation was 49.9 and 29.7%, respectively over 50% RDF.

Table 2. Effect of drip irrigation and fertigation on seed yield, stover yield and water use efficiency

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Water use efficiency (kg ha^{-1} mm^{-1})
Drip irrigation (I)			
I_1- 0.6 PEF	623	1231	2.09
I_2- 0.8 PEF	878	1495	2.31
I_3- 1.0 PEF	813	1377	1.75
S.Em.±	23	34	0.06
C.D. at 5%	74	111	0.19
C.V.%	16	12	14.73
Fertigation (F)			
F_1- 50% RDF	613	1185	1.61
F_2- 75% RDF	723	1320	1.91
F_3- 100% RDF	831	1428	2.22
F_4- 125% RDF	919	1537	2.45
S.Em.±	26	31	0.07
C.D. at 5%	74	88	0.20
C.V.%	14	10	12.47
I x F			
S.Em.±	45	53	0.12
C.D. at 5%	129	153	0.35

Interaction Effect

The pooled data on interaction effect of drip irrigation scheduling and fertigation levels presented in Table 3 revealed that treatment combination of drip irrigation at 0.8 PEF and fertigation with 125% RDF emerged out as the best treatment combination and recorded significantly the highest grain and stover yield of 1026 and 1634 kg ha^{-1}, respectively. However it was remained at par with treatment combinations I_3F_4 and I_2F_3

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Table 3. Interaction effect of drip irrigation and fertigation on seed and stover yields (pooled)

Fertigation levels	Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
	I_1	I_2	I_3	I_1	I_2	I_3
F_1	447	735	656	977	1347	1233
F_2	558	828	784	1156	1488	1317
F_3	712	925	855	1336	1512	1434
F_4	773	1026	956	1457	1634	1521
S.Em.±		45			53	
C.D. at 5%		129			153	

Economics

The mean data presented in Table 4 indicated that drip irrigation at 0.8 PEF and application of 125% RDF through fertigation recorded the highest gross return (` 113035 ha$^{-1}$), net return (` 74504 ha^{-1}) and BCR (2.94), while the lowest gross return (` 49456 ha$^{-1}$), net return (` 14440 ha^{-1}) and BCR (1.42) were registered under drip irrigation at 0.6 PEF with application of 50% RDF through fertigation.

Table 4. Economics of drip irrigation and fertigation in cumin (mean)

Treatment combinations	Gross return (` ha^{-1})	Net return (` ha^{-1})	BCR
$I_1 F_1$	49456	14440	1.42
$I_1 F_2$	61659	25508	1.71
$I_1 F_3$	78413	41068	2.10
$I_1 F_4$	85395	46863	2.22
$I_2 F_1$	81005	45989	2.32
$I_2 F_2$	91332	55182	2.53
$I_2 F_3$	101929	64584	2.73
$I_2 F_4$	113035	74504	2.94
$I_3 F_1$	72368	37352	2.07
$I_3 F_2$	86477	50326	2.40
$I_3 F_3$	94312	56967	2.53
$I_3 F_4$	104545	66947	2.72

CONCLUSION

It could be concluded from the present two-year investigation that drip irrigation at 0.8 PEF at three days with a lateral between two rows of cumin having drippers spaced at 37.5 cm with the discharge of 4 LPH and application of 125% RDF through fertigation in 5 equal splits at 15 days interval enhanced the productivity, profitability and water use efficiency of cumin.

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