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Productivity, nutrient uptake, quality and economics of cumin as affected by time and rate of nitrogen fertilization

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Abstract

A field experiment was conducted in three rabi season from 2010-11 to 2012-13 at Center for Research on Seed Spices, S.D. Agricultural University, Jagudan to find out the optimum rate and time of nitrogen application on growth and yield of cumin. The twelve treatments were evaluated in randomized block design. The growth and yield attributing characters were not significantly influenced by nitrogen rates and time of application, except, numbers of umbels plant^{-1} on pooled basis. Nitrogen management significantly influenced the seed yield of cumin. In general, increase in numbers of splits from 2 to 3 as well as increase in rate of nitrogen up to 40 kg ha^{-1} increased seed yield. The maximum seed yield was recorded with application at 40 kg N ha^{-1} in three equal splits and was at par with application of 50 kg N ha^{-1} in three equal splits, but significantly superior over rest of the treatments except in the year 2011-12.However, the minimum seed yield of cumin was recorded when crop was fertilized with 20 kg N ha^{-1} only at 8-30 DAS. Application at 30 kg N ha^{-1} in three equal split recorded higher seed yield than crop fertilized with 40 or 50 kg ha^{-1} in two equal splits at basal and 30 DAS, but differences were non significant. Thus, nitrogen fertilization in three equal splits found better than two equal splits.

Key words : Cumin, nutrient uptake, nitrogen fertilization, yield

Introduction

Cumin (*Cuminum cyminum L.)* is short duration seed spice crop of arid and semi arid regions of India. Due to low requirement of inputs and sensitive to slight change in climatic condition and higher market price, it is termed as low volume with high value but risky crop. Fertilizers are scare and costly input for crop production and farmers of these regions applied much more nutrients than recommended dose to seed spice crops for obtaining higher yield, which not only deteriorate the soil health but also increase cost of production. Light textured soils, suitable for cumin cultivation, which is poor in fertility and water holding capacity resulted in more leaching losses. For better germination and establishment of seedling, crop demands an extra irrigation at 8-10 days after sowing which may increase leaching losses of applied nitrogen. Thus, nitrogen management plays a vital role in minimizing the actual yield potential and average productivity. Scientific information on rate and time of nitrogen application on cumin crop is scanty. Hence, an experiment was planned to determine the effect of time and rate of nitrogen application on growth, yield and quality of cumin.

Materials and methods

In order to evaluate rate and time of nitrogen application on growth and yield of cumin crop, an investigation was carried out at Center for Research on Seed Spices, Sardarkrushinagar Dantiwada Agricultural University, Jagudan. The experiment farm is located in North Gujarat Agroclimatic Zone and characterized by sub-tropical monsoon type semi-arid climate with extreme cold winter, hot and dry windy summer.

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Soil texture was loamy sand in nature with low in both organic carbon (0.12 %) and nitrogen (135 kg ha^{-1}) but medium in available phosphorus (34 kg P_2O_5 ha^{-1}) and potassium (265 kg K_2O ha^{-1}). The treatments indicated as per table were framed out in randomized block design with three replication during *rabi* 2010-11 to 2012-13. The seeds of variety *Cv*. Gujarat Cumin 4 were sown manually at uniform depth in furrow at 30 cm apart with seed rate of 12 kg ha^{-1}.The entire quantity of phosphorus i.e. 15 kg ha^{-1} in the form of DAP was manually applied before sowing the crop in the furrows. The nitrogen as per treatment was applied in the form of urea after irrigation to each plot. To raise healthy crop, recommended production technologies were adopted. Observations on growth attributes, yield components and yield were recorded at harvest.

Composite soil sample from 0-30 cm soil depth was collected from each treatment in all the three replications. The soil samples were chemically analyzed for available nitrogen, phosphorus and potassium in soil. The estimation of nitrogen, phosphorus and potassium in seed and stover were also determined by method of Jackson (1978). The volatile oil content (%) of seed was estimated as per steam distillation method (A.O.A.C., 1970). The data have been analyzed for individual years as well as pooled as per standard procedure.

Result and discussion

Growth and yield attributes

Different nitrogen rates and time did not emerge any significant effect on growth and yield attributes except number of umbels/plant on pooled data (Table 1). Application of 20kg N ha^{-1} at 30 DAS (T_2) recorded significantly higher numbers of umbels $plant^{-1}$ over T_1 (20kg N ha^{-1} at 8-10 DAS) and T_{11} (50 kg N ha^{-1} at 8-10 and 30 DAS - 50% each)) and remained at par with rest of the treatments. With increased supply of nitrogen, the process of tissue differentiation from somatic to reproductive meristematic activity and development of floral primodia might have increased, resulting in more numbers of umbels per plant. The results are in line with the earlier reports of Jangir and Singh (1996) and Rajendra *et al.,* (1999).

Table 1. Growth and yield attributes of cumin as influenced by time and levels of nitrogen application (Pooled data of the years 2010-11 to 2012-13)

	Treatments	Plant height (cm)	No. of branches $plant^{-1}$	No. of umbels $plant^{-1}$	No. of umballates $umbel^{-1}$	No. of seeds $umballate^{-1}$	Test weight (g)	Volatile oil (%)
T_1	20 kg N ha^{-1} at 8-10 DAS	25.99	4.51	12.77	4.83	5.35	3.77	4.77
T_2	20 kg N ha^{-1} at 30 DAS	25.44	4.36	16.68	5.21	5.59	4.05	4.88
T_3	20 kg N ha^{-1} at 8-10 and 30 DAS (50%)	25.10	4.80	14.88	4.73	5.44	3.81	4.71
T_4	30 kg N ha^{-1} at basal and 30 DAS (50%)	25.93	4.47	16.65	4.84	5.10	3.75	4.84
T_5	30 kg N ha^{-1} at 8-10 and 30 DAS (50%)	25.37	4.54	16.25	4.65	5.47	3.81	4.79
T_6	30 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%)	26.25	4.61	15.06	4.87	5.16	3.71	4.58
T_7	40 kg N ha^{-1} at basal and 30 DAS (50%)	24.72	4.42	14.52	4.91	5.14	3.83	4.76
T_8	40 kg N ha^{-1} at 8-10 and 30 DAS (50%)	24.50	4.43	15.00	4.69	4.99	3.92	4.84
T_9	40 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%)	24.92	4.50	16.06	4.84	5.50	3.87	4.83
T_{10}	50 kg N ha^{-1} at basal and 30 DAS (50%)	25.96	4.54	15.98	5.02	5.25	4.05	4.92
T_{11}	50 kg N ha^{-1} at 8-10 and 30 DAS (50%)	25.70	4.47	13.31	4.99	5.28	3.95	4.87
T_{12}	50 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%e)	27.48	4.80	15.67	5.14	5.10	3.81	4.96
S Em ±		0.91	0.23	0.78	0.13	0.17	0.13	0.14
CD (P = 0.05)		NS	NS	2.22	NS	NS	NS	NS
CV %		10.7	15.7	15.5	8.14	10.01	10.50	9.22
Y x T		NS	NS	NS	NS	NS	NS	NS

Seed yield

The seed yield of cumin (Table 2) was significantly influenced by different treatments of nitrogen management during the course of investigation and in pooled data also. In general, increase in numbers of splits from 2 to 3 increased seed yield, similarly increase in rate of nitrogen up to 40 kg ha^{-1} increased seed yield. The maximum seed yield was recorded with application at 40 kg N ha^{-1} in three equal splits (T_9) and was at par with application of 50 kg N ha^{-1} in three equal splits (T_{12}),but significantly superior over rest of the treatments except in the year 2011-12 where, it was at par with treatments T_{12},T_{11},T_8 and T_7. However, the minimum seed yield of cumin was recorded when crop was fertilized with 20 kg N ha^{-1} only at 8-30 DAS (T_1). Application at 30 kg N ha^{-1} in three equal split (T_6) recorded higher seed yield than crop fertilized with 40 or 50 kg ha^{-1} in two equal splits (T_7, T_{10} and T_{11}) however, differences were non-significant. Thus, nitrogen fertilization in three equal splits found better than two equal splits. Increased trend as observed in seed yield was evidently due to cumulative effect of increasing trend recorded on major yield attributing characters viz., numbers of umbels per plant and numbers of seeds per umbellate as well as seed weight. These finding are in accordance with Patel *et al.,* (1992) and Jangir and Singh (1996). Similarly, time of nitrogen application also made remarkable effect on seed yield. The maximum seed yield was recorded with more split which might be due to judicious quantity of available nitrogen throughout crop growth period. Cumin have nature of delay germination and required one more irrigation for better germination and establishment of crop, which might be increased leaching losses of nitrogen consequently reduced seed yield under application of nitrogen one or two splits. The findings are closely associated with Bhati (1990), Gora *et al.,* (1996a) and Yadav and Sharma (2004).

Table 2. Seed (Kg ha^{-1}) yield of cumin as influenced by time and levels of nitrogen application

	Treatments	**Cumin seed yield (Kg ha^{-1})**			
		2010-11	**2011-12**	**2012-13**	**Pooled**
T_1	20 kg N ha^{-1} at 8-10 DAS	331	351	449	377
T_2	20 kg N ha^{-1} at 30 DAS	412	392	472	426
T_3	20 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	436	427	542	468
T_4	30 kg N ha^{-1} at basal and 30 DAS (50%each)	393	385	517	432
T_5	30 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	411	410	547	456
T_6	30 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%each)	437	437	554	476
T_7	40 kg N ha^{-1} at basal and 30 DAS (50%each)	390	424	532	448
T_8	40 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	439	469	538	482
T_9	40 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%each)	562	503	674	580
T_{10}	50 kg N ha^{-1} at basal and 30 DAS (50%each)	379	410	543	444
T_{11}	50 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	415	451	549	472
T_{12}	50 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%each)	516	472	595	528
S Em ±		38	28	36	19
CD (P = 0.05)		110	81	105	55
CV %		15.26	11.24	11.39	12.62
Y x T		NS	NS	NS	NS

Effect on uptake of nutrients

Effect on nitrogen uptake

Removal of nitrogen by crop was significantly influenced by different treatments of nitrogen management (Table 3). The maximum uptake of nitrogen by crop was recorded when 40 kg N ha^{-1} applied in three equal splits (T_9) and was at par with the treatment T_{12} in 2010-11 and on pooled basis and with treatments T_5, T_6, T_{11} and T_{12} in the year 2011-12. While in the year 2012-13, treatment T_{12} (50 kg N ha^{-1} applied in three equal splits) removed maximum nitrogen over rest of the treatments except T_5, T_6, T_9 and T_{11}. The minimum removal of nitrogen by crop which was significantly higher was recorded with application of 20 kg N ha^{-1} at 8-10 DAS (T_1). Better availability of nitrogen and reduction of leaching losses of nitrogen under more splits might be increased nitrogen uptake by crop. The results are coinciding with the reports of Sivakumaran *et al*., (1996) and Gora *et al.,* (1996 b).

Effect on phosphorus uptake

As like as nitrogen uptake by crop, phosphorus removal by crop (Table 4) was the maximum with treatment T_9 and was at par with the treatments T_{12} but significantly superior over rest of the treatments during course of investigation and in pooled data also, except during the year 2011-12, where T_9 was statistically near to equal with treatment T_{12} and T_8. The minimum uptake of phosphorus was recorded under application of 20 kg N ha^{-1} (T_1). This might be due to better availability of nitrogen and favourable effect of split application of nitrogen on yield attributes of cumin and reducing leaching losses of nitrogen which ultimately increase seed and straw yields and consequently higher uptake of phosphorus by seed and straw and crop. The results are in line with the results recorded by Gora *et al.,* (1996 b).

Table 3. Uptake of nitrogen (Kg ha^{-1}) by cumin crop as influenced time and levels of nitrogen application

Treatments		Nitrogen uptake by crop (Kg ha^{-1})			
		2010-11	2011-12	2012-13	Pooled
T_1	20 kg N ha^{-1} at 8-10 DAS	9.52	10.13	11.81	10.49
T_2	20 kg N ha^{-1} at 30 DAS	11.80	11.82	12.50	12.04
T_3	20 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	12.88	13.12	13.45	13.15
T_4	30 kg N ha^{-1} at basal and 30 DAS (50%each)	11.50	11.97	14.75	12.74
T_5	30 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	12.18	12.50	15.91	13.53
T_6	30 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%each)	12.89	13.24	15.31	13.81
T_7	40 kg N ha^{-1} at basal and 30 DAS (50%each)	11.78	13.07	13.99	12.95
T_8	40 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	13.31	14.52	13.99	13.94
T_9	40 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%each)	17.03	15.49	17.61	16.71
T_{10}	50 kg N ha^{-1} at basal and 30 DAS (50%each)	11.43	12.96	14.24	12.88
T_{11}	50 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	12.50	13.96	15.38	13.95
T_{12}	50 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%each)	16.48	15.29	17.95	16.58
	S Em ±	1.14	0.91	1.00	0.59
	CD (P = 0.05)	3.35	2.67	3.00	1.67
	CV %	15.47	11.98	11.78	13.06
	Y x T	-	-	-	NS

Table 4. Uptake of phosphorus by cumin crop as influenced by time and levels nitrogen of application

Treatments		Phosphorus uptake by crop (Kg ha^{-1})			
		2010-11	2011-12	2012-13	Pooled
T_1	20 kg N ha^{-1} at 8-10 DAS	2.47	2.93	3.83	3.08
T_2	20 kg N ha^{-1} at 30 DAS	3.99	3.68	4.52	4.06
T_3	20 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	4.41	4.45	5.24	4.70
T_4	30 kg N ha^{-1} at basal and 30 DAS (50%each)	4.57	4.31	5.56	4.81
T_5	30 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	4.73	4.18	5.78	4.90
T_6	30 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%each)	4.98	4.79	5.97	5.25
T_7	40 kg N ha^{-1} at basal and 30 DAS (50%each)	4.38	4.57	5.92	4.96
T_8	40 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	5.04	5.25	6.06	5.45
T_9	40 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%each)	6.88	5.75	7.89	6.84
T_{10}	50 kg N ha^{-1} at basal and 30 DAS (50%each)	3.70	3.99	5.39	4.36
T_{11}	50 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	4.10	4.58	5.33	4.67
T_{12}	50 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%each)	6.20	5.55	7.32	6.36
	S Em ±	0.41	0.25	0.48	0.23
	CD (P = 0.05)	1.21	0.72	1.40	0.64
	CV %	15.49	9.80	14.38	13.69
	Y x T	-	-	-	NS

Table 5. Uptake of potassium by cumin crop as influenced by time and levels nitrogen of application

Treatments		Potassium uptake (Kg ha^{-1})			
		2010-11	2011-12	2012-13	Pooled
T_1	20 kg N ha^{-1} at 8-10 DAS	5.25	5.94	7.92	6.37
T_2	20 kg N ha^{-1} at 30 DAS	6.67	7.17	8.88	7.57
T_3	20 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	7.44	7.97	10.04	8.49
T_4	30 kg N ha^{-1} at basal and 30 DAS (50%each)	7.19	7.04	9.73	7.987
T_5	30 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	7.20	7.67	10.20	8.36
T_6	30 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%each)	9.88	8.55	11.65	10.03
T_7	40 kg N ha^{-1} at basal and 30 DAS (50%each)	8.23	8.51	10.76	9.17
T_8	40 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	9.91	9.35	10.64	9.97
T_9	40 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%each)	12.74	10.58	14.29	12.54
T_{10}	50 kg N ha^{-1} at basal and 30 DAS (50%each)	7.87	8.17	11.05	9.03
T_{11}	50 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	8.53	9.04	10.84	9.47
T_{12}	50 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%each)	12.08	10.14	13.72	11.98
	S Em ±	0.89	0.82	0.92	0.51
	CD (P = 0.05)	2.61	2.40	2.71	1.43
	CV %	17.94	16.99	14.79	16.45
	Y x T	-	-	-	NS

Effect of potash uptake

Effect of different treatments on uptake of potash by cumin crop was significant during the course of investigation and on pooled data (Table 5).The maximum removal of potash by crop was recorded with application of 40 kg N ha^{-1} in three equal splits (T_9) and was at par with treatments T_{12} in the year 2010-11 and in pooled data, with treatments T_6, T_7, T_8, T_{10}, T_{11} and T_{12} in the year 2011-12 and treatments T_8 and T_{12} in the year 2012-13. However, it was the minimum with treatment T_1 i.e. application of 20 kg N ha^{-1} at 8-10 DAS.

Available nitrogen status in soil

The status of nitrogen was significantly influenced by different treatments of nitrogen rate and time during course of investigation and pooled basis (Table 6).

Maximum Nitrogen status of soil was recorded with application of 50 kg N ha^{-1} (T_{10}) and was at par with treatmentsT_{11},T_{12},T_9,T_8 and T_7 significantly superior over rest of the treatments except in pooled data where it was at par with treatments T_{17}, T_{11} and T_7 Whereas, it was the minimum with treatment T_3.

Economics

As like seed yield, the maximum gross and net realizations as well as benefit cost ratio BCR (Table 7) were recorded with application of nitrogen at 40 kg ha^{-1} in three equal splits as basal, 8-10 DAS and 30 DAS (T_8) which was closely followed by treatment T_{12} i.e. fertilized the crop with 50 kg N ha^{-1} in three equal splits. Whereas, these were the minimum under application of nitrogen at 20 kg ha^{-1} at 8-10 DAS.

Table 6. Available nitrogen status in soil at harvest as influenced by time and levels nitrogen of application

	Treatments	Available nitrogen (Kg ha^{-1})			
		2010-11	2011-12	2012-13	Pooled
T_1	20 kg N ha^{-1} at 8-10 DAS	143	137	135	138
T_2	20 kg N ha^{-1} at 30 DAS	141	129	131	133
T_3	20 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	140	128	131	133
T_4	30 kg N ha^{-1} at basal and 30 DAS (50%each)	148	147	142	145
T_5	30 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	148	143	140	144
T_6	30 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%each)	140	143	137	140
T_7	40 kg N ha^{-1} at basal and 30 DAS (50%each)	161	155	153	156
T_8	40 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	156	152	150	153
T_9	40 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%each)	152	150	152	151
T_{10}	50 kg N ha^{-1} at basal and 30 DAS (50%each)	169	165	158	164
T_{11}	50 kg N ha^{-1} at 8-10 and 30 DAS (50%each)	167	163	157	162
T_{12}	50 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%each)	159	158	154	157
	S Em ±	6	5	6	3
	CD (P = 0.05)	17	15	18	9
	CV %	6.51	6.03	7.35	6.64
	Y x T	-	-	-	NS

Table 7. Economics of the different treatments of time and levels of nitrogen application

Treatments		Seed yield (Kg ha^{-1})	Gross realization (₹ ha^{-1})	Gross expenditure (₹ ha^{-1})	Net return (₹ ha^{-1})	BCR
T_1	20 kg N ha^{-1} at 8-10 DAS	377	47106	31550	15556	1.5
T_2	20 kg N ha^{-1} at 30 DAS	426	53197	31550	21647	1.7
T_3	20 kg N ha^{-1} at 8-10 and 30 DAS (50%)	468	58521	31723	26798	1.8
T_4	30 kg N ha^{-1} at basal and 30 DAS (50%)	432	53993	31704	22289	1.7
T_5	30 kg N ha^{-1} at 8-10 and 30 DAS (50%)	456	57002	31877	25125	1.8
T_6	30 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%)	476	59534	31877	27657	1.9
T_7	40 kg N ha^{-1} at basal and 30 DAS (50%)	448	56062	31856	24206	1.8
T_8	40 kg N ha^{-1} at 8-10 and 30 DAS (50%)	482	60257	32029	28228	1.9
T_9	40 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%	580	72482	32029	40453	2.3
T_{10}	50 kg N ha^{-1} at basal and 30 DAS (50%)	444	55497	32010	23488	1.7
T_{11}	50 kg N ha^{-1} at 8-10 and 30 DAS (50%)	472	58955	32183	26772	1.8
T_{12}	50 kg N ha^{-1} at basal, 8-10 and 30 DAS (33.3%)	528	65972	32183	33789	2.0

Price :
Cumin seed ₹ 125 kg^{-1}
Nitrogen : ₹ 13.26 kg^{-1} (Urea)
Phosphorus : ₹ 46.25 kg^{-1} (SSP)

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