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EFFECT OF VARYING LEVELS OF NITROGEN AND SULPHUR ON GROWTH AND YIELD OF CORIANDER (*CORIANDRUM SATIVUM* L.)

C. B. PATEL[1]*, A. U. AMIN[2] AND A. L. PATEL
[1]Department of Agronomy, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar - 385 506 (Gujarat), INDIA
[2]Centre for Seed Spices, S.D. Agricultural University, Jagudan - 385 506 (Gujarat), INDIA
e-mail: chiragpatel12286@yahoo.com

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***Corresponding author**

ABSTRACT
A field experiment was conducted on loamy sand soil of Agronomy Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *rabi* season of 2009-10 to investigated effect of varying levels of nitrogen and sulphur on growth and yield of coriander (*Coriandrum sativum* L.). Sixteen treatment combinations consisting of four levels each of nitrogen (20, 40, 60 and 80 kg N/ha) and sulphur (0, 10, 20 and 30 kg S/ha) replicated four times. Among the levels of nitrogen @ 80 kg ha^{-1} sowed its producing highest seed yield (1203 kg ha^{-1}) and straw yield (1596 kg ha^{-1}). The highest performance is attributed to significant improvement in growth and yields parameters *viz.,* plant height, number of branches plant^{-1}, number of umbels plant^{-1}, number of umbellate umbel^{-1}, number of seeds umbellate^{-1}, Test weight (g) and seed weight plant^{-1} (g). Similarly application of nitrogen @ 80 kg ha^{-1} recorded highest quality parameters (protein content, volatile oil content and total oil yield) and uptake of nitrogen and sulphur . Among the levels of sulphur @ 30 kg ha^{-1} recorded significantly higher seed yield (1184 kg ha^{-1}) and straw yield (1577 kg ha^{-1}). Sulphur application @ 30 kg ha^{-1} significant improvement in growth and yield parameters *viz.,* number of branches plant^{-1}, number of umbels plant^{-1}, test weight (g) and seed weight plant^{-1} (g). Application of sulphur @ 30 kg ha^{-1} also showed positive effect on protein, volatile oil content and total oil yield as well as uptake of nitrogen and sulphur.

INTRODUCTION

India is the world's largest producers, consumers and exporter of seed spices. Among all the states of India, Gujarat and Rajasthan together contribute more than 80 per cent of the total seed spices production in the country and thus, both the states together are known as "seed spices bowl" of India. Coriander (*Coriandrum sativum* L.) is an annual herb from *umbelliferae* family with 90 to 120 days growth period. Coriander leaves are being used in cooking, flavouring, beverages *etc.,* and seeds are being used for preparing value added products such as coriander powder, dhana dal, curry powder, oleoresin and essential oil. So, it is known as low volume but high value crop of arid and semi arid regions.

Among the primary nutrients, nitrogen has a considerable effect, not only on quality of produce but on quantity of produce also. Nitrogen is one of the major elements for growth and development of plant. It is involved in photosynthesis, respiration and protein synthesis. It impart the dark green colour of the leaves, promotes vigorous vegetative growth and more efficient use of available inputs finally leads to higher productivity. At Parbhani (Maharashtra), an experiment was conducted during the *rabi* season of 2003-2004 to study effect of nitrogen rates (50, 75 and 100 kg/ha) and spacing on coriander. Application of nitrogen at a rate of 100 kg/ha resulted in the maximum plant height, number of leaves per plant, number of primary branches per plant, number of secondary branches per plant, east-west spread of the plant, fresh weight of plant and yield per hectare (Pawar *et al*., 2007).

Sulphur is a secondary plant nutrient but now considered as the fourth major plant nutrients after nitrogen, phosphorus and potash. It is essential for synthesis of several vitamins and amino acids i.e., cystine, cysteine and methionine and it helps in photosynthesis and nitrogen fixation. At Bangalore, a field experiment was conducted by Sivkumaran *et al*. (1996) on coriander during with application of nitrogen, phosphorus and sulphur (0 and 10 kg/ha). Oil content and oil yield of coriander were improved by application of sulphur. The highest oil yield of 2.48 kg/ha was observed when crop fertilized with 10 kg S/ha. Uptake of nitrogen, phosphorus and sulphur by plants were also increased significantly with increase in sulphur levels from 0 to 10 kg/ha.

Productivity of coriander is low as compared to actual yield potential due to incorrect application of agro techniques particularly nutrient management under North Gujarat condition. So, the present investigation was carried out for evaluating the optimum requirement of nitrogen and sulphur for loamy sand soil of North Gujarat, which are poor in nitrogen and sulphur status and find out the effect of varying levels of nitrogen and sulphur on growth and yield of coriander.

MATERIALS AND METHODS

The field experiment was conducted at Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar

Dantiwada Agricultural University, Sardarkrushinagar (North Gujarat), during *rabi* 2009-10. The soil of experimental field was loamy sand in texture, low in organic carbon and available nitrogen, medium in available phosphorus and rich in available potassium. Sixteen treatment combinations consisting of four levels each of nitrogen (N_1-20, N_2-40, N_3-60 and N_4-80 kg ha^{-1}) and sulphur (S_1-0, S_2-10, S_3-20 and S_4-30 kg ha^{-1}) were evaluated in Randomized Block Design with factorial concept and replicated four times. Coriander variety Gujarat Coriander 2 was sown 20 kg/ha to a depth of 3 to 4 cm in the first week of November. Elemental sulphur was applied before the 21 days as per treatments and the crop was uniformly fertilized with 10 kg P_2O_5 ha^{-1} as basal dose. As per treatments, the crop was fertilized with nitrogen in two equal splits. Half dose of nitrogen was applied as basal before sowing and remaining half dose was applied as top dressing at 30 days after sowing. Nitrogen (basal and top dressed) and phosphorus were applied form of urea and DAP. All the recommended cultural and plant protection measures were followed throughout the experimentation. Following methods applied for determination of different components are below.

Harvest index is the ratio of economic yield to the biological yield per plot. It was calculated by using the formula given by Donald and Hamblin (1962). Seed samples were digested in Micro-Kjeldhal's for nitrogen estimation. Protein content of the seeds was estimated by multiplying the nitrogen values by 6.25 (Bhuiya and Chudhari, 1974). Volatile oil content of the seed was estimated as per steam distillation method (AOAC, 1970).

The nitrogen from seed and straw samples was determined by using Micro Kjeldhal's method (Jackson, 1978). The sulphur from seed and straw samples was determined by using turbidity method (Chaudhary and Cornfield, 1966).

RESULTS AND DISCUSSION

Effect of different treatments on growth and yield attributes as well as on yield of coriander

Effect of nitrogen

At harvest, the tallest plants were found with application of 80 kg N/ha, which was 0.13, 4.53 and 8.04 per cent higher as compared to 60, 40 and 20 kg N/ha, respectively. The magnitude of increase in primary branches per plant with 80 kg N/ha was 1.72, 8.44 and 16.50 per cent, respectively over 60, 40 and 20 kg N/ha. Similarly, the extent of increase in secondary branches per plant with application of 80, 60 and 40 kg N/ha were 16.50, 15.18 and 8.82 per cent, respectively over 20 kg N/ha. Crop was fertilized with 80 kg N/ha, recorded 16.94, 8.44 and 1.62 per cent higher tertiary branches per plant as compared to lower levels of nitrogen *i*.e., 20, 40 and 60 kg/ha, respectively. This might be due to favourable function of nitrogen, being a major structural constituent of cell, help in stimulating the cell division and cell elongation. This finding are corroborate the results reported by Baboo and Rana (1995), Naghera *et al*. (2000) and Pawar *et al*. (2007).

The yield attributing characters *viz*., number of umbels per plant, number of umbellates per umbel, number of seeds per umbellate, test weight as well as seed weight per plant recorded under higher levels of nitrogen application (40, 60 and 80 kg/ha) were at par and remarkably higher than the lowest level of nitrogen (20 kg/ha) except in case of number of umbellates per umbel and number of seeds per umbellate where 60 and 40 kg N/ha were not differ remarkably. In comparison with 20 kg N/ha, the extent of increase in number of umbels per plant with application of 40, 60 and 80 kg N/ha were 8.11, 12.46 and 12.77 per cent, respectively. Likewise, the percentage of rise in number of umbellates per umbel with application of 80 kg N/ha was 18.29 over those of 20 kg N/ha. The present finding further confirmed the earlier reports of Baboo and Rana (1995) and Naghera *et al*. (2000). Number of seeds per umbellate in general increased with increase in nitrogen levels from 20 to 80 kg/ha. However, differences between 60 and 80 kg N/ha were not remarkable. As compared to 20 kg N/ha, the percentage of increase in seeds per umbellate under 80, 60 and 40 kg N/ha were 18.39, 17.41 and 9.79, respectively. The present findings are close accordance with the reports of Ughreja and Chundawat (1992[b]) and Baboo and Rana (1995).

The magnitude of increase in test weight under higher levels of nitrogen i.e., 80, 60 and 40 kg/ha were 13.58, 13.25 and 8.65, respectively over the lowest dose of nitrogen (20 kg/ha). As compared to 20 kg N/ha, the respective increases in percentage in seed weight per plant were 9.47, 13.19 and 13.52 with treatments of 40, 60 and 80 kg N/ha. The findings are closely in agreement with Ughreja and Chundawat (1992b), Baboo and Rana (1995), Naghera *et al*. (2000) and Shroff (2003).

The seed yield increased with increase in the levels of nitrogen but significant increase was observed up to 40 kg N/ha. The respective percentage increase in seed yield under application of nitrogen @ 40, 60 and 80 kg/ha was 8.22, 12.51 and 12.80 over that of with 20 kg N/ha. Relative consistency in seed yield with increase in nitrogen dose from 20 to 80 kg N/ha indicated that the application of nitrogen greater than 40 kg N/ha may not be beneficial for harvesting economical yield of coriander. The straw yield followed the similar pattern of seed yield and it increased with increase in doses of nitrogen. As compared to 20 kg N/ha, respective rise in straw yield with 40, 60 and 80 kg N/ha were 5.69, 9.42 and 9.71 per cent. The better effect of nitrogen levels might be attributed to rapid expansion of dark green foliage, which could intercept and utilize more incidence light energy in the production of food through the process of photosynthesis. Thus, increased production of food helped in increasing plant height, number of primary, secondary and tertiary branches per plant, which might be responsible for higher seed and straw yield. Similar finding are also reported by Naghera *et al*. (2000), Shroff (2003), Rampratap *et al*. (2003) and Patel (2005[a]). The harvest index was not remarkably influenced by levels of nitrogen.

Effect of sulphur

The magnitudes of rise in primary branches per plant with application of 10, 20 and 30 kg S/ha were 8.93, 14.28 and 14.78 per cent, respectively. Similarly, the extent of increase in secondary branches per plant with application of 30, 20 and 10 kg S/ha were 14.91, 14.13 and 9.10 per cent, respectively over 0 kg S/ha. The treatment 30 kg S/ha recorded 0.56, 6.39 and 14.91 per cent higher tertiary branches per

Table 1: Effect of varying levels of nitrogen and sulphur on growth and yield of coriander

Treatment	Plant height (cm) at harvest	Number of branches plant^{-1}			Number of umbels plant^{-1}	Number of umbellate umbel^{-1}	Number of seeds umbellate^{-1}
		Primary	Secondary	Tertiary			
Nitrogen (N) (kg/ha)							
(N_1):20	68.61	4.35	7.54	12.79	14.61	5.27	4.79
(N_2):40	71.23	4.77	8.27	14.10	15.90	5.84	5.31
(N_3):60	74.51	5.12	8.89	15.15	16.69	6.38	5.80
(N_4):80	74.61	5.21	9.03	15.40	16.75	6.45	5.87
SEm ±	0.884	0.09	0.17	0.29	0.32	0.16	0.14
CD at 5	2.519	0.27	0.48	0.83	0.92	0.45	0.41
Sulphur (S) (kg/ha)							
(S_1):0	70.55	4.38	7.59	12.88	14.73	5.73	5.21
(S_2):10	72.70	4.81	8.35	14.23	16.28	5.98	5.44
(S_3):20	72.73	5.11	8.87	15.12	16.44	6.05	5.50
(S_4):30	72.97	5.14	8.92	15.20	16.49	6.18	5.61
SEm ±	0.88	0.09	0.17	0.29	0.32	0.16	0.14
CD at 5	NS	0.27	0.48	0.83	0.92	NS	NS
Interaction (N × S)	NS	NS	NS	NS	NS	NS	NS
CV (%)	4.89	7.99	7.49	7.55	7.57	10.60	10.59

Table 2: Effect of varying levels of nitrogen and sulphur on yield and quality of coriander

Treatment	Test weight(g)	Seed weight plant^{-1} (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)	Protein content (%)	Volatile oil content (%)	Total oil yield(%)
Nitrogen (N) (kg/ha)								
(N_1):20	13.61	4.54	1049	1441	42.10	13.29	0.41	4.35
(N_2):40	14.90	4.97	1143	1528	42.73	14.55	0.47	5.44
(N_3):60	15.69	5.23	1199	1591	42.73	15.32	0.49	5.93
(N_4):80	15.75	5.25	1203	1596	43.09	15.38	0.51	6.16
SEm ±	0.32	0.16	23	25	01	0.32	0.02	0.27
CD at 5 %	0.92	0.44	64	72	NS	0.90	0.05	0.76
Sulphur (S) (kg/ha)								
(S_1):0	13.73	4.58	1058	1450	42.15	13.41	0.41	4.36
(S_2):10	15.28	5.09	1170	1556	42.73	14.93	0.48	5.60
(S_3):20	15.44	5.15	1181	1574	42.82	15.08	0.50	5.97
(S_4):30	15.49	5.16	1184	1577	42.95	15.12	0.51	5.98
SEm ±	0.32	0.16	23	25	01	0.32	0.02	0.27
CD at 5 %	0.92	0.44	64	72	NS	0.90	0.05	0.76
Interaction (N × S)	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	8.83	10.55	10.31	8.54	9.00	8.39	8.12	15.44

Table 3: Effect of varying levels of nitrogen and sulphur on uptake by coriander

Treatment	Nitrogen uptake by seed(kg ha^{-1})	Nitrogen uptake by straw(kg ha^{-1})	Nitrogen uptake by crop(kg ha^{-1})	Sulphur uptake by seed(kg ha^{-1})	Sulphur uptake by straw(kg ha^{-1})	Sulphur uptake by crop (kg ha^{-1})
Nitrogen (N) (kg/ha)						
(N_1):20	23.31	16.83	40.15	2.29	2.19	4.48
(N_2):40	27.26	19.17	46.43	2.73	2.55	5.29
(N_3):60	31.31	21.22	52.54	3.03	2.81	5.85
(N_4):80	31.92	21.43	53.35	3.14	2.90	6.04
SEm ±	1.03	0.71	1.70	0.18	0.09	0.20
CD at 5 %	2.95	2.04	4.87	0.30	0.26	0.57
Sulphur (S) (kg/ha)						
(S_1):0	23.63	17.04	40.68	2.35	2.26	4.61
(S_2):10	28.56	19.97	48.54	2.79	2.60	5.39
(S_3):20	30.69	20.78	51.48	3.01	2.80	5.82
(S_4):30	30.94	20.87	51.78	3.03	2.81	5.84
SEm ±	1.03	0.71	1.70	0.18	0.09	0.20
CD at 5 %	2.95	2.04	4.87	0.30	0.26	0.57
Interaction (N × S)	NS	NS	NS	NS	NS	NS
CV (%)	14.56	14.59	14.20	15.44	14.31	14.79

plant as compared to 20, 10 and 0 kg S/ha, respectively. The maximum number of umbels per plant recorded when crop received 30 kg S/ha and was at par with 20 and 10 kg S/ha but significantly superior over 0 kg/ha. These results are in close confirmity with the findings of Rampratap *et al*. (2003), Patel (2005[a]) and Patel (2005[b]).

The extent of increase in number of umbels per plant with application of 30, 20 and 10 kg S/ha were 10.67, 10.40 and 9.52 per cent, respectively over 0 kg S/ha. However, number of umbellates per umbel and number of seeds per umbellate

were not differed remarkably due to application of different levels of sulphur. Similar finding are also reported by Rampratap *et al*. (2003) and Patel (2005b). The extent of increase in test weight with application of 30, 20 and 10 kg S/ ha was 11.36, 11.07 and 10.14 per cent over 0 kg S/ha. In comparison with 0 kg S/ha, per cent rise of in seed weight per plant under treatments of 30, 20 and 10 kg S/ha was 11.24, 11.06 and 10.01, respectively. Increasing trend in these attributes due to sulphur application were also reported earlier by Rampratap *et al*. (2003), Patel (2005a) and Patel (2005b).

Marked effect on seed yield due to sulphur application was noticed up to 10 kg S/ha. Per cent rise in seed yield due to application of 10, 20 and 30 kg S/ha were 9.57, 10.41 and 10.64 over 0 kg S/ha, respectively. The harvest index was not remarkably influenced by increasing levels of sulphur. Increased content of sulphur in plant helped in better development and thickening of xylem, collenchyma tissue, such favourable effects might have resulted in stronger stem and increasing photosynthetic as well as meristematic activities which might have promoted vegetative growth consequently resulted in more straw yield. These results are in line of work reported by Sivkumaran *et al*. (1996), Rampratap *et al*. (2003) and Patel (2005b). The harvest index was not remarkably influenced by increasing levels of sulphur.

Role of different treatments on quality parameters

Effect of nitrogen

The magnitude of increase in protein content with 40, 60 and 80 kg N/ha were 8.65, 13.25 and 13.58 per cent, respectively over 20 kg N/ha. Increase in protein content ascribed to increase in nitrogen uptake at higher levels of nitrogen and also as nitrogen plays an important role in synthesis of amino acid, which constitutes building blocks of protein and that might have resulted in higher protein content. Similar increasing trend in protein content with nitrogen application was also reported by Sivkumaran *et al*. (1996) and Patel (2005a). The per cent rise in volatile oil content of seed with 80 kg N/ha was 3.92, 7.84 and 19.60 over 60, 40 and 20 kg N/ha, respectively. Similarly, per cent rise in volatile oil yield due to 80 kg N/ha was 3.73, 11.68 and 29.54 over 60, 40 and 20 kg/ ha, respectively. These findings are in conformity with the report of Patel (2005a) and Naghera *et al*. (2000).

Effect of sulphur

The extent of increase in protein content with application of 30, 20 and 10 kg S/ha were 11.30, 11.07 and 10.18 per cent, respectively over without sulphur application. The beneficial effect of sulphur fertilization might be because of the fact that sulphur is a constituent of amino acid i.e., biotin, cystine and methionine, which present in protein and further, it also participates in several biochemical reactions eventually resulting in increased protein content. These results are in accordance with the findings of Patel (2005a) and Patel (2002b). The magnitude of increase in volatile oil content with 10, 20 and 30 kg S/ha was 14.58, 18.00 and 19.60 per cent over without sulphur application. Similarly, per cent rise in oil yield with application of 30, 20 and 10 kg S/ha were 27.09, 26.92 and 22.14 over without sulphur application, respectively. The increase in oil content due to application of sulphur might be attributed to increased availability of nutrients owing to favourable environment created by sulphur and also it plays a significant role in overall biosynthesis processes. Sulphur is also constituent of glutathione, a synthesis of essential oils. On the contrary, plant growing in sulphur deficient soils may have a limited capacity to synthesize these enzymes, resulting in decrease oil content. A significant increase in oil yield seems owing to the cumulative effect of increase in oil content and seed yield in response to application of sulphur. Beneficial effect of sulphur on oil content and oil yield was also observed by Sivkumaran *et al*. (1996).

Effect of various treatments on nitrogen and sulphur uptake by crop

Effect of nitrogen

The magnitude of increase in nitrogen uptake by crop under 80, 60 and 40 kg N/ha were 27.74, 23.58 and 13.52 per cent, respectively over that of with 20 kg N/ha. The results are in agreement with the report of Ughreja and Chundawat (1992[a]) and Sivkumaran *et al*. (1996).

Marked response of varying levels of nitrogen on sulphur uptake by seed, straw and crop were also observed up to 60 kg N/ha. The per cent rise in removal of sulphur by crop was 25.82 per cent under 80 kg N/ha and 23.41 per cent under 60 kg N/ha as compared to that of with 20 kg N/ha. These may be due to the favourable effect of nitrogen on growth and yield attributes of coriander as explained earlier which ultimately increases seed and straw yields and consequently higher uptake of nitrogen and sulphur by crop. Thus, increased availability of nutrients in root zone coupled with increased metabolic activity at the cellular level might have increased the nitrogen and sulphur uptake. These results are in line of work reported by Sivkumaran *et al*. (1996) and Patel (2005a).

Effect of sulphur

The magnitude of increase in removal of nitrogen by crop with 30, 20 and 10 kg S/ha was 25.82, 23.41 and 15.31 per cent, respectively over without sulphur application.

Sulphur uptake significantly increased with increase in the levels of applied sulphur from 0 to 30 kg/ha. As compared to without sulphur fertilization, the magnitude of increase in sulphur uptake by crop under 30, 20 and 10 kg S/ha was 21.06, 20.79 and 14.47, respectively. Favourable effect of adequate sulphur fertilization on growth and yield attributes as well as seed and straw yield of coriander as explained earlier, which might be increased nitrogen and sulphur uptake by crop. These results are in line of work reported Sivkumaran *et al*. (1996) and Patel (2005b).

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