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Effect of integrated nutrient management on growth of off season leafy coriander (*Coriandrum sativum* L.) under different growing condition

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Abstract
The present study was conducted in the year 2018 during summer season at College of Horticulture, S.D. Agricultural University, Jagudan, Dist. Mehsana, Gujarat to find out the effect of integrated nutrient management on growth of off season leafy coriander (*Coriandrum sativum* L.) under different growing condition. The experiment was laid out in split plot design with three replications. Three different growing condition (g_1)-50% white shade net; (g_2)-50% green shade net; (g_3)-Open field condition and six integrated nutrient management (INM) treatments *viz.*, m_1: 100% RDF through chemical fertilizer (60:60:30 NPK kg ha^{-1}); m_2: 100% RDN through urea; m_3: 75% RDN through urea + 25% N through FYM; m_4 : 50% RDN through urea + 50% N through FYM; m_5: 75% RDN through urea + 25% N through FYM + *Azotobacter* @ 2.5 lit /ha + PSB @ 2.5 lit /ha; m_6: 50% RDN through urea + 50% N through FYM + *Azotobacter* @ 2.5 lit /ha + PSB @ 2.5 lit /ha. Treatments were evaluated with respect to growth parameters of off season leafy coriander. Among three growing conditions, 50% green shade net performed significantly superior over open field with respect to early germination (6.44 days), plant height (17.84, 17.00 and 16.50 cm), number of tillers (5.10, 5.80 and 5.73) at first and subsequent cuttings and INM treatment m_5 (75% RDN through urea + 25% N through FYM + *Azotobacter* @ 2.5 lit /ha + PSB @ 2.5 lit /ha) was found significantly superior with respect to plant height (18.39, 17.82 and 16.92 cm) and number of tillers (5.34, 6.48 and 6.37) at first and subsequent cuttings, respectively, whereas, minimum days taken for germination (6.81 days) was recorded with same treatment.

Keywords: INM, coriander, FYM, *Azotobacter*, PSB, plant height, number of leaves and leaf area

Introduction
Coriander (*Coriandrum sativum* L.) is an annual herbaceous plant belongs to the family Apiaceae and originated in the Mediterranean region. Coriander is one of the important seed spices crop that is commonly called as *Dhania* in India. It is grown in *rabi* season and major part of cultivated area in Rajasthan, Gujarat and Madhya Pradesh states. This spice is used as common flavoring essences which not only add flavour and taste to our food, but also enhance keeping quality of food. The stem, leaves and grain have a pleasant aroma and dry seeds are extensively used in the form of powder in number of culinary preparations.

The green herb is also consumed on a large scale in India, China, Thailand, Malaysia, Indonesia and American Midwest. Fresh leaves coriander is very much liked by the consumers in curriers, sauces, soups and different culinary preparations. Coriander is rich source of dietary fibre, manganese, iron, magnesium, vitamins (C and K), protein and small amount of calcium, phosphorous, potassium, thiamine, niacin and carotene. Van Soest *et al*. (1991) have reported leafy vegetables to contribute significant amount of vitamins and minerals to the human diet and are also an excellent sources of protein, carotene, iron and ascorbic acid.

The cultivation of vegetable crops in off season under shade net house condition helps to provide availability in the market round the year and it also a profitable venture. Vegetables grown under open field conditions are exposed to abiotic and biotic stress which affects productivity and quality. The protected cultivation has the potential to reduce the stresses and offset the vagaries of weather (Singh *et al.*, 2006) [9]. However, the profitability of protected cultivation depends upon the choice of structure, selection of crop, varieties, production technology and market price (Rajasekar *et al.*, 2013) [8]. Due to this backdrop, a field experiment was attempted to assess the performance of leafy vegetables under protected environment during summer season.

Improper nutrient management is one of the major reasons accountable for low yield and poor quality. Integrated nutrient management (INM) refers to the “maintenance of soil fertility and plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of organic, inorganic and biological compounds in an integrated approach.” Use of organic manures not only helps to sustain crop yields but also plays a key role in improving soil health. Organic sources of nitrogen have close relation with plant growth, yield and quality of coriander. Farm yard manure (FYM) is the cheap source of organic matter in our country and its application helps in proper supply of essential plant nutrients and sustainable production. Organic manures improve the physico-chemical properties as well as encourage the microbial activities of soil. Use of biofertilizers can have a great complementary impact in increasing fertilizer use efficiency. The application of *Azotobacter* and PSB cultures along with organic manures enhances nitrogen level in soil by symbiotically N-fixation, whereas, phosphorus availability increased by conversion of organic or fixed phosphorus in soil. The balance nutrient application through INM practices helps in the improvement of plant physiology that builds levels of resistance and reduces the incidence of disease and pest attacks (Mirchandani and Mirchandani, 2005) [7]. Increasing resistance power through efficient nutrition programmes can thus reduce the application of harmful and expensive pesticides and makes farming more profitable, sustainable and environment friendly. But there is a need to address the question as by which source or combination of sources of nutrients would be cheap and effective under suitable growing condition in off season for coriander crop.

Materials and methods

The experiment was conducted at College of Horticulture, S.D. Agricultural University, Jagudan, Dist. - Mehsana (Gujarat). The area having semi-arid climate and falls under North Gujarat Agro-Climatic Zone-IV.

The soil samples were collected from the experimental site before sowing of the test crop and analyzed using standard methods. The analyzed soil having loamy sand in texture, low in organic carbon, slightly alkaline reaction with non saline in nature, low in available nitrogen, medium in available phosphorus and potassium. The FYM was also analyzed using standard methods for NPK content on dry weight basis and found 0.51% N, 0.22% P_2O_5 and 0.52% K_2O.

The experiment was carried out in different shade net and open field condition during summer season, 2018. The variety of coriander, Gujarat Dantiwada Leafy Coriander 1 was taken under investigation and conduct experiment in split plot design with three replications. The main plot has three different growing conditions (g_1)-50% white shade net; (g_2)-50% green shade net; (g_3)-Open field condition and six integrated nutrient management treatments *viz.*, m_1: 100% RDF through chemical fertilizers (60:60:30 NPK kg ha^{-1}); m_2: 100% RDN through urea; m_3: 75% RDN through urea + 25% N through FYM; m_4 : 50% RDN through urea + 50% N through FYM; m_5: 75% RDN through urea + 25% N through FYM + *Azotobacter* @ 2.5 lit /ha + PSB @ 2.5 lit /ha; m_6: 50% RDN through urea + 50% N through FYM + *Azotobacter* @ 2.5 lit /ha + PSB @ 2.5 lit /ha.

The FYM was applied 15 days before sowing as per treatments, whereas biofertilizers (*Azotobacter* and PSB) applied at the time of sowing. Half amount of N through urea was given per plot as basal dose and remaining amount of N applied as top dressing after 30 days of sowing. In treatment m_1, 100% dose of RDF for phosphorus and potassium was applied through SSP and MOP, respectively as a basal dose.

Growth Parameters

Days taken for germination

The number of days taken to germinate from date of sowing was counted for each treatment.

Plant height at 45 days after sowing and each subsequent cuttings

The height of ten randomly selected plants was measured in centimeter with the help of meter scale at 45 days after sowing i.e. at first cutting and subsequent cuttings. The height was taken from the soil surface of the plant up to the longest growing tip and average was worked out.

Number of tillers per plant at 45 days after sowing and each subsequent cuttings

Total ten plants from each plot was selected randomly and used to record the number of primary branches at 45 DAS and averaged to express braches per plant.

Leaf area per plant (cm^2)

The leaf area of ten randomly selected plants was measured with the help of leaf area meter (Leaf area meter- 211, Systronics, India) and average value was worked out and recorded.

Results and Discussion

Effect of different growing condition and INM on days taken for germination

Perusal of data presented in Table 1 indicated that days taken for germination was significantly influenced in various growing conditions, whereas effect of integrated nutrient management and its interaction was found not significant.

Significantly minimum days taken for germination (6.44) was recorded in treatment g_2 (50% green shade net) which was at par with treatment g_1 (50% white shade net). While, maximum days taken for germination (8.05) was observed in treatment g_3 (open field). The data also showed that there was non-significant difference was found for effect of different integrated nutrient management treatments and its interaction on days taken for seed germination.

Days taken for germination, plant height and leaf area represents the vegetative growth and it was found better in 50 per cent green shade net which might be due to favourable growing condition. According to Dixit (2007) [3] favourable environmental conditions stimulate cell division and cell enlargement in the growing apex of the plant resulting in better growth. These results are in conformity with the findings of Karetha *et al.* (2014) [6] in coriander.

Table 1: Effect of different growing condition and INM on days taken for germination

Treatments	Days taken for germination
Growing conditions (G)	
50% white shade net (g_1)	6.89
50% green shade net (g_2)	6.44
Open field condition (g_3)	8.05
S.Em. ±	0.10
C.D. (p=0.05)	0.39
C.V. (%)	6.01
Integrated nutrient management (M)	
100% RDF through chemical fertilizer (60:60:30 NPK kg/ha) (m_1)	7. 31
100% RDN through urea (m_2)	7.21
75% RDN through urea + 25% N through FYM (m_3)	7. 39
50% RDN through urea + 50% N through FYM (m_4)	7. 02
75% RDN through urea + 25% N through FYM + Azotobacter @ 2.5 lit/ha + PSB @ 2.5lit/ha (m_5)	6.81
50% RDN through urea + 50% N through FYM + Azotobacter @ 2.5 lit /ha + PSB @ 2.5 lit /ha (m_6)	7. 02
S.Em. ±	0.14
C.D. (p=0.05)	NS
Interaction	
S.Em. ±	0.24
C.D. (p=0.05)	NS
C.V. (%)	5.80

Effect of different growing condition and INM on plant height at 45 days and at each subsequent cuttings

Data presented in Table 2 showed that plant height was significantly influenced for different growing condition and integrated nutrient management, while its interaction effect was found not significant. Significant effect of growing condition on plant height was observed and maximum height of plant was recorded at first (17.84 cm), second (17.00 cm) and third (16.50 cm) cuttings under treatment g_2 (50% green shade net) which was at par with g_1 (50% white shade net). Minimum plant height at first (14.56 cm), second (13.98 cm) and third (13.29 cm) cuttings were found in g_3 treatment (open field condition). Moreover, the maximum plant height at first (18.39 cm), second (17.82 cm) and third (16.92 cm) cuttings were observed with treatment m_5 (75% RDN through urea + 25% N through FYM + *Azotobacter* @ 2.5 lit/ha + PSB @ 2.5 lit/ha) which was at par with m_6 (50% RDN through urea + 50% N through FYM + *Azotobacter* @ 2.5 lit /ha + PSB @ 2.5 lit /ha). Whereas, minimum plant height at first (15.45 cm), second (14.83 cm) and third (13.95 cm) cuttings were recorded with treatment m_2 (100% RDN through urea) which was at par with m_1 (100% RDF through chemical fertilizer).

Plant height was found better in 50 per cent green shade net which might be due to favourable growing condition. Present findings are in close accordance with the research work of Kale *et al.* (1997) [5] and they reported that vegetative growth of cucumber in net house was magically high as compared to that in open field, which supports to the present results. These results are also comparable with the work of Dixit (2007) [3] in vegetable crops. The application of different doses of fertilizers, FYM and biofertilizers significantly influenced the plant height which besides supplying all the essential plant nutrients and also improves physical condition of soil. The results obtained in present investigation corroborated with the findings of Singh (2015) [10] and Jhankar *et al.* (2017) [4] in coriander.

Table 2: Effect of different growing condition and integrated nutrient management on plant height at 45 days and at each subsequent cuttings

Treatments	Plant height (cm)		
	1st cutting	2nd cutting	3rd cutting
Growing conditions (G)			
50% white shade net (g_1)	17.36	16.85	16.15
50% green shade net (g_2)	17.84	17.00	16.50
Open field condition (g_3)	14.56	13.98	13.29
S.Em. ±	0.29	0.28	0.25
C.D. (p=0.05)	1.13	1.08	0.99
C.V. (%)	7.37	7.35	6.99
Integrated nutrient management (M)			
100% RDF through chemical fertilizer (60:60:30 NPK kg/ha) (m_1)	15.67	14.91	14.55
100% RDN through urea (m_2)	15.45	14.83	13.95
75% RDN through urea + 25% N through FYM (m_3)	16.10	15.67	15.08
50% RDN through urea + 50% N through FYM (m_4)	15.88	15.15	14.88
75% RDN through urea + 25% N through FYM + *Azotobacter* @ 2.5 lit/ha + PSB @ 2.5lit/ha (m_5)	18.39	17.82	16.92
50% RDN through urea + 50% N through FYM + Azotobacter @ 2.5 lit /ha + PSB @ 2.5 lit /ha (m_6)	18.04	17.29	16.52
S.Em. ±	0.38	0.33	0.31
C.D. (p=0.05)	1.09	0.96	0.88
Interaction			
S.Em. ±	0.65	0.57	0.53
C.D. (p=0.05)	NS	NS	NS
C.V. (%)	6.8	6.22	5.97

Effect of different growing condition and integrated nutrient management on number of tillers per plant at 45 days and at each subsequent cuttings

The data given in Table 3 indicated that tillers per plant at each subsequent cuttings was significantly influenced for its growing condition except in first cutting and effect of integrated nutrient management in first and subsequent cuttings, whereas interaction effect was found not significant in all the cuttings. However, significant effect of growing condition was found on number of tillers per plant in second and third cuttings.

The maximum number of tillers per plant at second (5.80) and third (5.73) cutting was observed under treatment g_2 (50% green shade net) and minimum number of tillers per plant at second (4.99) and third (4.93) cuttings in g_3 treatment (open field condition). Maximum number of tillers per plant in first cutting (5.34), second cutting (6.48) and third cutting (6.37) with treatment m_5 (75% RDN through urea + 25% N through FYM + *Azotobacter* @ 2.5 lit/ha + PSB @ 2.5 lit /ha) which was at par with m_6 (50% RDN through urea + 50% N through FYM + *Azotobacter* @ 2.5 lit /ha + PSB @ 2.5 lit /ha).Whereas, minimum number of tillers per plant at each subsequent cuttings were recorded with treatment m_2 (100% RDN through urea).

The combined use of FYM, chemical fertilizers and biofertilizers enhanced availability of nutrients and growth promoting substances that might have caused cell enlargement and cell multiplication which is directly correlated to the plant height and number of leaves. These results are conformity with the findings of Tripathi *et al.* (2013) [11] and Jhankar *et al.* (2017) [4] in coriander.

Table 3: Effect of different growing condition and integrated nutrient management on number of tillers per plant at 45 days and at each subsequent cuttings

Treatments	Number of tillers		
	1st cutting	2nd cutting	3rd cutting
Growing conditions (G)			
50% white shade net (g_1)	4.89	5.56	5.43
50% green shade net (g_2)	5.10	5.80	5.73
Open field condition (g_3)	4.72	4.99	4.93
S.Em. ±	0.09	0.10	0.09
C.D. (p=0.05)	NS	0.38	0.33
C. V. (%)	7.50	7.43	6.74
Integrated nutrient management (M)			
100% RDF through chemical fertilizer (60:60:30 NPK kg/ha) (m_1)	4.76	5.14	5.05
100% RDN through urea (m_2)	4.66	4.89	4.87
75% RDN through urea + 25% N through FYM (m_3)	4.76	4.97	4.90
50% RDN through urea + 50% N through FYM (m_4)	4.73	4.97	4.92
75% RDN through urea + 25% N through FYM + Azotobacter @ 2.5 lit/ha + PSB @ 2.5lit/ha (m_5)	5.34	6.48	6.37
50% RDN through urea + 50% N through FYM + Azotobacter @ 2.5 lit /ha + PSB @ 2.5 lit/ha (m_6)	5.19	6.26	6.07
S.Em. ±	0.11	0.11	0.11
C.D. (p=0.05)	0.33	0.32	0.33
Interaction			
S.Em. ±	0.2	0.20	0.20
C.D. (p=0.05)	NS	NS	NS
C. V. (%)	7.01	6.18	6.32

Effect of different growing condition and integrated nutrient management on leaf area per plant

Data pertaining to leaf area per plant presented in Table 4 which was significantly affected for different growing conditions while effect of integrated nutrient management and interaction was found not significant.

Significantly maximum leaf area per plant (50.19 cm^2) was observed in treatment g_2 (50% green shade net) which was at par with g_1 (50% white shade net). However, the effect of INM on leaf area was found maximum in treatment m_5 (75% RDN through urea + 25% N through FYM + *Azotobacter* @ 2.5 lit/ha + PSB @ 2.5lit/ha).

The better growth and development might be increased due to availability of nitrogen to the plants initially through chemical fertilizers and by their FYM/organic sources, corresponding to the need of plants throughout the cropping season. Integrated use of organic and inorganic fertilizers increased crop yield and maintains long term soil fertility (Brar *et al.*, 2015) [1]. Dadiga *et al.* (2015) [2] also reported a significant increase in growth parameters due to application of FYM with chemical fertilizers. The results obtained in present investigation are in line with the findings of Singh (2015) [10] and Jhankar *et al.* (2017) [4] in coriander.

Table 4: Effect of different growing condition and integrated nutrient management on leaf area per plant

Treatments	Leaf area per plant (cm^2)
Growing conditions (G)	
50% white shade net (g_1)	49.43
50% green shade net (g_2)	50.19
Open field condition (g_3)	39.29
S.Em. ±	0.63
C.D. (p=0.05)	2.47
C. V. (%)	5.77
Integrated nutrient management (M)	
100% RDF through chemical fertilizer (60:60:30 NPK kg/ha) (m_1)	46.37
100% RDN through urea (m_2)	45.25
75% RDN through urea + 25% N through FYM (m_3)	45.25
50% RDN through urea + 50% N through FYM (m_4)	45.82
75% RDN through urea + 25% N through FYM + Azotobacter @ 2.5 lit/ha + PSB @ 2.5lit/ha (m_5)	48.02
50% RDN through urea + 50% N through FYM + Azotobacter @ 2.5 lit /ha + PSB @ 2.5 lit /ha (m_6)	47.05
S.Em. ±	0.80
C.D. (p=0.05)	NS
Interaction	
S.Em. ±	1.40
C.D. (p=0.05)	NS
C. V. (%)	5.23

Conclusion

The results of present study reflected that the application of 75% RDN through urea + 25% N through FYM + *Azotobacter* @ 2.5 lit/ha + PSB @ 2.5 lit/ha under 50% green shade net have significant effects on all the growth parameters of coriander crop.

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