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Influence of nitrogen and phosphorus levels on the growth attributes of coriander in *Inceptisol* of Raigarh district, Chhattisgarh

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Abstract
The present experiment entitled "Influence of Nitrogen and Phosphorus Levels on the Growth Attributes of Coriander in *Inceptisol* of Raigarh District, Chhattisgarh" was conducted during *rabi* season in year 2021-22 and 2022-23 at the Krishi Vigyan Kendra (KVK), Raigarh under the administrative jurisdiction of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The experiment was laid out in FRBD (Factorial Randomized Block Design) with 16 treatments and three replications. Factor A: Nitrogen levels has 4 treatments and Factor B: Phosphorus levels has 4 treatments. The treatment consists of N_1 (0 kg N ha^{-1}), N_2 (30 kg N ha^{-1}), N_3 (60 kg N ha^{-1}), N_4 (90 kg N ha^{-1}) at Factor A: Nitrogen levels and P_1 (0 kg P ha^{-1}), P_2 (30 kg P ha^{-1}), P_3 (60 kg P ha^{-1}), P_4 (90 kg P ha^{-1}) at Factor B: Phosphorus levels. The study revealed that nitrogen and phosphorus levels influenced coriander growth differently. The highest plant population was observed with treatment N_4 (90 kg N ha^{-1}) and P_4 (90 kg P ha^{-1}), while the lowest was recorded under the control treatments N_1 (0 kg N ha^{-1}) and P_1 (0 kg P ha^{-1}). Plant height increased significantly with nitrogen up to N_2 (30 kg N ha^{-1}) and phosphorus up to P_3 (60 kg P ha^{-1}), beyond which no significant rise occurred. The maximum number of branches per plant was recorded in N_4 (90 kg N ha^{-1}) and P_4 (90 kg P ha^{-1}), while the minimum was under N_1 and P_1. Days to 50% flowering and maturity were longest in N_4 (90 kg N ha^{-1}) and shortest in N_1 (0 kg N ha^{-1}), whereas phosphorus showed the opposite trend—earliest flowering and maturity under P_4 (90 kg P ha^{-1}) and latest under P_1 (0 kg P ha^{-1}). Overall, the findings indicate that balanced nitrogen and phosphorus application enhances the growth and phenological performance of coriander under *Inceptisol* conditions of Raigarh.

Keywords: Coriander, nitrogen levels, phosphorus levels, *Inceptisol*, growth parameters, Phenological traits, Factorial Randomized Block Design (FRBD), Raigarh, Chhattisgarh

Introduction
Coriander (*Coriandrum sativum* L.), commonly referred to as "Dhania," is an economically important seed spice and leafy herb belonging to the family Apiaceae, with a diploid chromosome number of 2n = 22. It is cultivated across diverse agro-climatic zones of India and serves dual purposes as a fresh leafy vegetable and as a spice crop. Owing to its aromatic foliage and seeds rich in essential oils, the crop holds significant culinary, medicinal, and industrial value. Its global adaptability and strong domestic market demand have positioned coriander among the most widely consumed and traded spices worldwide.

India remains the largest producer, consumer, and exporter of coriander, with major production concentrated in Madhya Pradesh, Rajasthan, Gujarat, Andhra Pradesh, Tamil Nadu, and Uttar Pradesh. According to recent estimates (Anonymous, 2021), the crop occupies 6.64 lakh hectares with a total production of 8.61 lakh metric tonnes. Despite its widespread cultivation, productivity remains comparatively low in several eastern regions, including Chhattisgarh, where traditional cultivars are still grown under nutrient-deficient soils and suboptimal management practices. In Chhattisgarh, coriander is cultivated predominantly by small and marginal farmers for both leaf and seed purposes, typically under rainfed, low-input conditions with limited adoption of scientific nutrient management. As reported by the Directorate of Horticulture (2021), the state has 14,988 hectares under coriander cultivation, producing 66,299 metric tonnes, with Raigarh district alone contributing significantly through 6,272 hectares under spice crops.

The soils of this region are primarily *Inceptisols*—moderately weathered, coarse-textured, and inherently low in available nitrogen (N) and phosphorus (P), the two key macronutrients governing coriander growth and seed production. Low soil fertility, inadequate nutrient supplementation, limited varietal improvement, and non-optimized fertilization schedules collectively constrain productivity. This highlights the need for scientifically tailored nutrient management strategies that focus on soil fertility restoration and balanced fertilization.

Soil fertility, defined as the ability of soil to supply essential nutrients in appropriate quantities for optimal plant growth, has declined in many Indian agro-ecosystems due to nutrient mining, imbalanced fertilizer application, and insufficient organic matter recycling. In the *Inceptisols* of central and eastern India, N and P deficiencies are particularly acute. Nitrogen is integral to chlorophyll formation, protein synthesis, and vegetative growth, and its adequate supply enhances leaf area, photosynthetic capacity, and seed development in coriander. However, excessive nitrogen may promote luxuriant vegetative growth at the expense of reproductive development (Pawar *et al.*, 2007) [10]. Phosphorus, essential for root proliferation, energy transfer (ATP), nucleic acid synthesis, and enzymatic regulation, governs flowering, seed setting, and overall nutrient uptake efficiency. Its availability is often restricted in Indian soils due to fixation and low mobility, especially under acidic or alkaline conditions.

The synergistic interaction of N and P plays a crucial role in enhancing seed yield, nutrient-use efficiency, essential oil content, and soil productivity. Therefore, determining their optimum application rates and economic thresholds is vital for sustainable coriander production. Although substantial research has been conducted on cereals and major horticultural crops, seed spices such as coriander remain comparatively under-studied, particularly in regions like Chhattisgarh. Farmers often rely on generalized fertilizer recommendations that fail to account for local soil nutrient status, climatic variations, and varietal responses, leading to poor nutrient-use efficiency and reduced economic returns.

In Raigarh district, where *Inceptisols* predominate and cultivation is primarily rainfed or semi-irrigated using local cultivars, there is an urgent need to formulate location-specific nutrient management strategies that improve soil health, enhance productivity, and increase profitability. The growing domestic demand for high-quality coriander seed, expanding export opportunities, and declining soil fertility collectively emphasize the importance of adopting climate-resilient and resource-efficient nutrient management approaches. Developing scientifically informed fertilization schedules tailored to local conditions is essential to harness the crop’s full yield potential while ensuring long-term sustainability.

Materials and Methods

The field experiment was conducted during the *Rabi* seasons of 2021-22 and 2022-23 at the research farm to assess the influence of nitrogen and phosphorus levels on the growth and yield attributes of coriander. The experiment was carried out using the recommended variety *Chhattisgarh Shri Chandrahashini Dhaniya-2*, which is widely cultivated in the region. Prior to sowing, composite soil samples were collected from the experimental field to determine baseline physico-chemical properties, particularly focusing on available nitrogen, phosphorus, and organic carbon status of the *Inceptisol* soil. These data served as a reference for interpreting the nutrient response under different treatment combinations.

The experimental layout followed a factorial Randomized Block Design (FRBD), accommodating four nitrogen levels (0, 30, 60, and 90 kg N ha^{-1}) and four phosphorus levels (0, 30, 60, and 90 kg P_2O_5 ha^{-1}). This resulted in a total of sixteen treatment combinations, each replicated three times, leading to forty-eight experimental plots. The gross plot size measured 4.0 × 3.0 m (12.0 m²), while the net plot area was maintained at 3.0 × 2.4 m (7.2 m²) to minimize border effects. Nitrogen was applied in the form of urea, while phosphorus was supplied as single super phosP hate (SSP). Phosphorus was applied as a basal dose at the time of sowing, whereas nitrogen was split into basal and top-dressing applications according to standard agronomic recommendations for coriander.

Sowing was done manually by line sowing at a uniform spacing, ensuring proper seed placement and optimum plant stand. Standard cultural practices—including irrigation, gap filling, weeding, thinning, and plant protection measures—were uniformly applied across all plots to avoid non-treatment variability. Observations on plant population, plant height, number of branches, phenological parameters (days to 50% flowering and maturity), and other parameters were recorded at different growth stages (30, 60, and 90 DAS, and at harvest). Data were subjected to statistical analysis using ANOVA appropriate for FRBD to assess the significance of treatment effects and their interactions across the two seasons and pooled data.

Results

The data regarding as influenced by various nitrogen and phosphorus levels has been presented in Table 1, Table 2, Table 3, Table 4 and Table 5.

Plant population at 30 DAS and at harvest

Nitrogen levels

Plant population was not significantly influenced by varying nitrogen levels from 0 to 90 kg N ha^{-1}. However, the maximum plant population was observed in the treatment receiving 90 kg N ha^{-1} (N_4), recording 32.86, 32.84, and 32.85 plants m^{-2} at 30 DAS, and 29.79, 30.31, and 30.01 plants m^{-2} at harvest during 2021-22, 2022-23, and pooled data, respectively. The lowest population was noted under the control (N_1: 0 kg N ha^{-1}), with values of 31.73, 31.75, and 31.74 plants m^{-2} at 30 DAS, and 29.25, 29.70, and 29.47 plants m^{-2} at harvest. A general decline in plant population was observed at harvest compared to 30 DAS.

Although statistically non-significant, nitrogen application tended to enhance plant population over control, likely due to improved vegetative vigor and crop establishment. These findings are consistent with the observations of Dubey *et al.* (2012) [3].

Phosphorus levels

Similar to nitrogen, phosphorus application had no significant effect on plant population. The highest values were observed with 90 kg P ha^{-1} (P_4), recording 32.96, 32.92, and 32.94 plants m^{-2} at 30 DAS, and 30.26, 30.23, and 30.01 plants m^{-2} at harvest during 2021-22, 2022-23, and pooled data, respectively. The lowest population was recorded under the control (P_1: 0 kg P ha^{-1}), with 31.79, 31.89, and 31.84 plants m^{-2} at 30 DAS, and 29.39, 29.56, and 29.41 plants m^{-2} at harvest.

Although statistically non-significant, plant population exhibited an increasing trend with higher phosphorus levels up to 90 kg P ha^{-1}. This may be attributed to phosphorus-induced improvement in root growth, early seedling establishment, and nutrient uptake, leading to better plant stand. These observations align with the findings of Singh (2011) [11]. Across all nitrogen and phosphorus levels, plant population was consistently higher at 30 DAS than at harvest, indicating a natural thinning over time and a relatively weak response of coriander to nutrient application under the experimental conditions.

Plant height at 30 DAS, 60 DAS and 90 DAS and at harvest

Nitrogen levels

The effect of nitrogen levels significantly affected the plant height up to treatment N_2 (30 kg N ha^{-1}) at all observation stages during both the season (2021-22, 2022-23) and their pooled mean. Plant heights did not increase significantly beyond 30 kg N ha^{-1} at almost both the seasons and their pooled mean. The lowest plant heights were recorded under control which did not receive any N application at all stages in both the seasons and pooled mean.

Higher nitrogen availability would have promoted better vegetative growth leading to increased plant height. The increase in nitrogen levels from 0 to 90 kg N/ha enhanced the plant height by around $10^{-1}5$% at different growth stages. Lowest plant height was observed in the control with no nitrogen applied. The results obtained in the present study are supported by the works of Diwan *et al.* (2018) [2].

Phosphorus levels

Similarly, P application levels increased the pant height significantly up to P_3 level that received P application of 60 kg ha^{-1} at almost all the observation stages (30, 60, 90 DAS and at harvest stage) in both the seasons and their pooled mean. Application of 90 kg ha^{-1} had no effect on plant height statistically. However, the data indicate that plant height increased with advancement of the crop growth up to harvest stage in both seasons and their pooled means.

The application of phosphorus led to a significant increase in plant height at different growth stages. Highest plant height was recorded with 60 kg P ha^{-1} owing to improved phosphorus availability for enhancing cell division and elongation. Lowest plant height obtained with 0 kg P ha^{-1} indicates the importance of phosphorus for better plant growth. Incremental increases in phosphorus application helped maximize the plant height. The results obtained in the present study are in the agreement with the results of other workers like Choudhary *et al.* (2020) [1].

Interaction (N x P)

Interaction effect of both the factors was not found significant for plant height at all the stages during the 2021-22, 2022-23 and their pooled mean respectively.

Number of branches plant^{-1}

Nitrogen levels

The number of branches plant^{-1}varied significantly with application of nitrogen levels from control to 90 kg N ha^{-1} at all the observation timing (growth stages) from 60, 90 DAS and at harvest during 2021-22, 2022-23 and their pooled mean. In contrast, treatment N_1 (0 kg N ha^{-1}) recorded the lowest number of branches in both the years and their pooled mean.

The number of branches plant^{-1} increased significantly with increasing nitrogen application up to 90 kg N ha^{-1}at different crop growth stages. Higher nitrogen availability would have enhanced the vegetative growth leading to more branching. The maximum branches were recorded with 90 kg N ha^{-1} due to better nitrogen nutrition of the crop. In contrast, zero nitrogen resulted in minimum branches indicating its importance for vegetative growth. The finding of present study is in accordance with those of Choudhary *et al.* (2020) [1] and Nisarata *et al.* (2020) [8].

Phosphorus levels

The number of branches plant^{-1}varied significantly with P application levels up to P_3 (60 kg P ha^{-1}), beyond that showed at par results in both the seasons at all observation stages however, interestingly their pooled mean data showed significant results up to the highest level of P application i.e. 90 kg ha^{-1} at all the growth stages (60, 90 DAS and at harvest). In contrast, treatment P_1 (0 kg P ha^{-1}) recorded the lowest number of branches plant^{-1}at all the growth stages (60, 90 DAS and at harvest) in both the seasons and their pooled mean.

The number of branches enhanced due to P application at different growth stages due to better vegetative growth and development of plant owing to ample phosphorus supply. Zero phosphorus resulted in minimum branches indicating its vital role in branching. Gradually increasing phosphorus levels helped maximize the branching attributing to enhanced phosphorus availability in soil. Similar results were also reported by Patel *et al.* (2019) [9] and Singh *et al.* (2019) [13].

Interaction (N x P)

Interaction effect of both the factors was found to be non-significant for branches plant^{-1} at all the stages during the 2021-22, 2022-23 and their pooled mean.

Days to 50% flowering and maturity

Nitrogen levels

Days to 50% flowering

The data showed that the nitrogen level of N_1 (0 kg N ha^{-1}) produced significantly early duration to 50% flowering (53.62, 55.15 and 54.38) which was at par with the treatment N_2 (30 kg N ha^{-1}) (54.32, 55.75 and 55.03). Conversely, the maximum days to 50% flowering were noted in N_4 (90 kg N ha^{-1}) (56.98, 58.39 and 57.69) during the year 2021-22, 2022-23 and their mean, respectively.

Days to maturity

The data further reveal that the nitrogen level of N_1 (0 kg N ha^{-1}) produced significantly early days to crop maturity (103.89, 105.14 and 104.52) which was at par with the treatment N_2 (30 kg N ha^{-1}) (104.89, 106.68 and 105.78). Conversely, the maximum days to plant maturity were noted in N_4 (90 kg N ha^{-1}) (108.818, 111.10 and 109.95) during the year 2021-22, 2022-23 and their pooled mean, respectively.

The observed acceleration in flowering as well as maturity time under no nitrogen and lower nitrogen (N_1 and N_2, respectively) application as compared to higher nitrogen

(N_4) may be attributed to nitrogen-mediated modulation of plant resource allocation and stress creation. Reduced nitrogen availability limits vegetative growth, triggering a stress-induced shift toward reproductive development to ensure survival under suboptimal conditions. This aligns with the "stress-induced flowering" hypothesis, where nutrient limitation promotes early flowering as an adaptive strategy. Conversely, higher nitrogen (N_4) prolongs vegetative growth by enhancing photosynthetic capacity and carbohydrate accumulation, delaying floral transition via sugar signalling pathways that interact with photoperiodic flowering regulators. The delayed flowering and maturity under N_4 likely reflect a trade-off between continued vegetative growth and reproductive investment under resource-rich conditions. Similar result was also reported by Tripathi *et al.* (2013) [14], and Lokhande *et al.* (2015) [6].

Phosphorus levels

Days to 50% flowering

The data clearly indicated that contrary to N application, P application reduced the 50% flowering and hence enhanced the maturity. Results show that highest phosphorus level (90 kg P ha^{-1}) produced significantly minimum days to 50% flowering (53.79 and 54.57) which was statistically at par with the next level of P application P3 (60 kg P ha^{-1}) (54.44 and 55.12) during the year 2021-22 and on mean basis respectively, however during 2022-23 the days taken to 50% flowering due to different level of phosphorus application was found to be non-significant. The maximum days to 50% flowering were noted in P_1 (0 kg P ha^{-1}) (56.75, 57.91 and 57.33) during the years 2021-22, 2022-23 and their pooled mean, respectively.

Days to maturity

The data also revealed that the different phosphorus levels did not show significant variations in days to crop maturity among phosphorus levels during the years 2021-22 and 2022-23, whereas in the pooled mean significantly minimum days to maturity of coriander was recorded under treatment, P_4(90 kg P ha^{-1}) (105.12) which was at par with the treatment P_3(60 kg P ha^{-1}) (106.01) and the maximum days to plant maturity was noted under treatment, P_1(0 kg P ha^{-1}) (109.48).

The number of days taken to 50% flowering was significantly reduced by phosphorus application. Maximum phosphorus level of 90 kg P ha^{-1} led to earliest flowering possibly by enhancing the root and vegetative growth. Minimum phosphorus delayed the flowering indicating the role of phosphorus in expediting the reproductive development. Highest dose resulted in lowest time taken to flower underscoring phosphorus's importance in hastening flower initiation process. These outcomes are consistent with findings of Jagdale and Dalve (2010) [5] and Singh *et al.* (2017) [12]. Likewise, phosphorus application aided in early maturity of coriander. Maximum phosphorus dose of 90 kg P ha^{-1} facilitated timely maturity likely by promoting better vegetative growth and yield attributes. Minimum or no phosphorus extended the maturity period indicating the role of phosphorus in hastening the developmental Phases. Higher phosphorus levels led to earliest harvest clearly depicting phosphorus's positive influence on reducing the crop duration. Similar study was also observed by Tripathi *et al.* (2013) [14].

Dry matter accumulation (g plant^{-1})

Nitrogen levels

Different nitrogen levels significantly influenced the dry matter accumulation of coriander at different stages of crop growth. At 30 DAS, significantly maximum dry matter accumulation (0.27, 0.39 and 0.33 g plant^{-1}) was recorded under the treatment N_4 (90 kg N ha^{-1}) while, the lowest dry matter accumulation (0.20, 0.26 and 0.23 g plant^{-1}) were noted in treatment N_1 (0 kg N ha^{-1}), during the 2021-22, 2022-23 and their pooled mean, respectively. Similarly, at 60 DAS, significantly higher dry matter accumulation i.e. 4.20, 5.5.7 and 4.89 g plant^{-1} were observed in treatment N_4 (90 kg N ha^{-1}) as compared to rest of the nitrogen levels, however the lowest dry matter accumulation was recorded under N_1 (0 kg N ha^{-1}) i.e. 2.25, 2.56 and 2.40 g plant^{-1}, during the 2021-22, 2022-23 and on mean basis, respectively. A similar trend of data was also recorded at 90 DAS and at harvest with significantly maximum dry matter accumulation of 11.79 and 16.06, 12.48 and 16.29, 12.14 and 16.18 during 2021-22, 2022-23 and on mean basis, respectively. The dry matter accumulation increased significantly with increasing nitrogen levels up to 90 kg N ha^{-1} at various crop growth stages. Maximum nitrogen dose facilitated higher dry matter production due to better vegetative growth. Minimum dry matter was noted in no nitrogen treatment indicating the importance of nitrogen in enhancing photosynthate translocation and partitioning. Thus, nitrogen plays a crucial role in dry matter accumulation in coriander. Similar result was also found by Singh *et al.* (2017) [12] and Hossain and Pariari (2018) [4].

Phosphorus levels

Different phosphorus levels also had a significant impact on dry matter accumulation of coriander. At 30 DAS, significantly maximum dry matter accumulation was observed in treatment P_4 (90 kg P ha^{-1}) i.e. 0.26, 0.38 and 0.32 g plant^{-1}, while, the lowest dry matter accumulation (0.20, 0.28 and 0.24 g plant^{-1}) were noted in P_1 (0 kg P ha^{-1}) during the 2021-22, 2022-23 and pooled mean, respectively. Likewise, at 60 DAS, treatment P_4 (90 kg P ha^{-1}) proved to be significantly superior over rest of the treatments regarding the dry matter accumulation with values of4.03, 5.21 and 4.62 g plant^{-1}, while the lowest dry matter accumulation were noted in treatment P_1 (0 kg P ha^{-1}) (2.39, 2.74 and 2.57 g plant^{-1}), during the 2021-22, 2022-23 and on mean basis, respectively. A similar trend of data was also recorded at 90 DAS and at harvest with significantly maximum dry matter accumulation of 11.34 and 15.66, 12.04 and 15.67, 11.69 and 15.67 during 2021-22, 2022-23 and on mean basis, respectively.

The dry matter accumulation increased significantly with increasing phosphorus levels up to 90 kg P ha^{-1} owing to better vegetative growth and development at different stages. Maximum phosphorus application facilitated higher photosynthate translocation resulting in peak dry matter. Minimum phosphorus led to lowest dry weight indicating its vital role in dry matter partitioning. Thus, adequate phosphorus is important for improved dry matter production in coriander. The results obtained in the present study are supported by the works of Mehta *et al.* (2012) [7]. Increased growth parameter with increasing level of phosphorus was also recorded by Hossain and Pariari (2018) [4].

Interaction (N x P)

Interaction effect of both the factors was found to be non-significant with respect to dry matter at all the stages of crop growth, during both the years and their pooled mean.

Table 1: Effect of nitrogen and phosphorous levels on plant population at 30 DAS and at harvest of coriander.

Treatment	Plant population (m^{-2})					
	30 DAS			At harvest		
	2021-22	2022-23	Mean	2021-22	2022-23	Mean
Nitrogen levels						
N_1-0 kg N ha^{-1}	31.73	31.75	31.74	29.25	29.71	29.57
N_2-30 kg N ha^{-1}	32.41	32.11	32.26	29.39	29.70	29.47
N_3-60 kg N ha^{-1}	32.72	32.58	32.65	29.54	30.16	29.88
N_4-90 kg N ha^{-1}	32.86	32.84	32.85	29.79	30.31	30.01
SEm ±	0.40	0.33	0.29	0.26	0.21	0.16
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
Phosphorus levels						
P_1-0 kg P ha^{-1}	31.79	31.89	31.84	29.39	29.56	29.41
P_2-30 kg P ha^{-1}	32.36	32.06	32.21	29.54	29.93	29.66
P_3-60 kg P ha^{-1}	32.61	32.40	32.51	29.79	30.15	29.85
P_4-90 kg P ha^{-1}	32.96	32.92	32.94	30.26	30.23	30.01
SEm ±	0.40	0.33	0.29	0.26	0.21	0.16
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
NxP						
SEm ±	0.80	0.66	0.59	0.53	0.42	0.32
CD (P = 0.05)	NS	NS	NS	NS	NS	NS

Table 2: Effect of nitrogen and phosphorous levels on plant height at 30 DAS, 60 DAS and 90 DAS and at harvest of coriander.

Treatment	Plant height (cm)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2021-22	2022-23	Mean	2021-22	2022-23	Mean	2021-22	2022-23	Mean	2021-22	2022-23	Mean
Nitrogen levels												
N_1-0 kg N ha^{-1}	10.58c	11.07c	10.82d	41.94c	46.63d	44.29d	85.55c	87.61c	86.58c	89.88c	90.76b	90.32c
N_2-30 kg N ha^{-1}	11.67b	11.79b	11.73c	51.68b	53.96c	52.82c	90.31b	91.04cb	90.68b	94.11b	96.11a	95.11b
N_3-60 kg N ha^{-1}	12.39ab	12.41b	12.40b	54.17ab	57.97b	56.07b	92.60ab	94.82ab	93.71ab	96.19ab	98.54a	97.36ab
N_4-90 kg N ha^{-1}	12.84a	13.09a	12.97a	57.67a	62.55a	60.11a	94.30a	96.43a	95.36a	98.87a	99.90a	99.38a
SEm ±	0.25	0.23	0.16	0.94	1.09	0.82	1.20	1.65	1.07	1.22	1.77	1.04
CD (P = 0.05)	0.73	0.68	0.48	2.72	3.15	2.37	3.49	4.77	3.11	3.54	5.13	3.00
Phosphorus levels												
P_1-0 kg P ha^{-1}	10.85c	11.06c	86.67c	45.98c	49.35c	47.67c	86.67c	87.37c	87.02c	90.68b	91.73b	91.21c
P_2-30 kg P ha^{-1}	11.81b	11.83b	90.26ab	50.80b	55.35b	53.07b	90.26ab	91.81b	91.0b	94.49a	95.95a	95.22b
P_3-60 kg P ha^{-1}	12.26a	12.38a	92.09a	54.09a	57.08a	55.58a	92.09a	94.73ab	93.41a	96.47a	97.88a	97.17a
P_4-90 kg P ha^{-1}	12.57a	12.66a	93.74a	54.60a	59.32a	56.96a	93.74a	95.99a	94.87a	97.41a	99.75a	98.58a
SEm ±	0.25	0.16	1.20	0.94	1.09	0.82	1.20	1.65	1.07	1.22	1.77	1.04
CD (P = 0.05)	0.73	0.48	3.49	2.72	3.15	2.37	3.49	4.77	3.11	3.54	5.13	3.00
N x P												
SEm ±	0.51	0.47	0.33	1.88	2.18	1.64	2.41	3.30	2.15	2.45	3.55	2.08
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Effect of nitrogen and phosphorous levels on number of branches at 60, 90 DAS and at harvest.

Treatment	Number of branches plant^{-1}								
	60 DAS			90 DAS			At harvest		
	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest
Nitrogen levels									
N_1-0 kg N ha^{-1}	4.00d	4.41d	4.20d	5.70d	5.84c	5.77d	6.02c	6.12c	4.99d
N_2-30 kg N ha^{-1}	4.60c	4.87c	4.73c	6.24c	6.74b	6.49c	6.80b	7.04b	6.92c
N_3-60 kg N ha^{-1}	4.85b	5.22b	5.04b	6.56b	7.21a	6.88b	6.99b	7.07b	7.03b
N_4-90 kg N ha^{-1}	5.07a	5.44a	5.26a	6.87a	7.51a	7.19a	7.36a	7.79a	7.57a
SEm ±	0.071	0.07	0.05	0.10	0.15	0.07	0.13	0.12	0.10
CD (P = 0.05)	0.20	0.21	0.15	0.28	0.44	0.21	0.38	0.36	0.30
Phosphorus levels									
P_1-0 kg P ha^{-1}	4.12c	4.47c	4.29d	5.79c	5.98c	5.88d	6.27c	6.44d	6.36d
P_2-30 kg P ha^{-1}	4.65b	4.92b	4.78c	6.26b	6.84b	6.55c	6.65b	6.88c	6.76c
P_3-60 kg P ha^{-1}	4.80a	5.20a	5.00b	6.55a	7.13a	6.84b	7.01a	7.16b	7.08b
P_4-90 kg P ha^{-1}	4.95a	5.36a	5.15a	6.76a	7.36a	7.06a	7.23a	7.54a	7.39a
SEm ±	0.07	0.07	0.05	0.10	0.15	0.07	0.13	0.12	0.10
CD (P = 0.05)	0.20	0.21	0.15	0.28	0.44	0.21	0.38	0.36	0.30
N x P									
SEm ±	0.14	0.14	0.10	0.19	0.30	0.15	0.26	0.25	0.21
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4: Effect of nitrogen and phosphorous levels on days to 50% flowering and days to maturity

Treatment	Days to 50% flowering			Days to maturity		
	2021-22	2022-23	Mean	2021-22	2022-23	Mean
Nitrogen levels						
N_1-0 kg N ha^{-1}	53.62a	55.15a	54.38a	103.89a	105.14a	104.52a
N_2-30 kg N ha^{-1}	54.32ab	55.75b	55.03b	104.89ab	106.68ab	105.78b
N_3-60 kg N ha^{-1}	55.56b	56.44b	56.00b	106.56b	108.34b	107.45b
N_4-90 kg N ha^{-1}	56.98b	58.39b	57.69b	108.81b	111.10b	109.95b
SEm ±	0.74	0.68	0.41	1.18	1.29	0.73
CD (P = 0.05)	2.15	1.98	1.19	3.42	3.74	2.10
Phosphorus levels						
P_1-0 kg P ha^{-1}	56.75a	57.91a	57.33a	108.26a	110.70a	109.48a
P_2-30 kg P ha^{-1}	55.50ab	56.66a	56.08ab	106.36a	107.83a	107.09ab
P_3-60 kg P ha^{-1}	54.44b	55.81a	55.12b	105.14a	106.88a	106.01bc
P_4-90 kg P ha^{-1}	53.79b	55.35a	54.57b	104.39a	105.85a	105.12c
SEm ±	0.74	0.68	0.41	1.18	1.29	0.73
CD (P = 0.05)	2.15	NS	1.19	NS	NS	2.10
N x P						
SEm ±	1.49	1.37	0.82	2.36	2.59	1.46
CD (P = 0.05)	NS	NS	NS	NS	NS	NS

Table 5: Effect of nitrogen and phosphorous levels on dry matter accumulation of coriander at 30 DAS, 60 DAS and 90 DAS and at harvest

Treatment	Dry matter accumulation (g plant^{-1})											
	30 DAS			60 DAS			90 DAS			At harvest		
	2021-22	2022-23	Mean	2021-22	2022-23	Mean	2021-22	2022-23	Mean	2021-22	2022-23	Mean
Nitrogen levels												
N_1-0 kg N ha^{-1}	0.20d	0.26d	0.23d	2.25d	2.56d	2.40d	6.42d	6.64d	6.53d	8.14d	8.55d	8.34d
N_2-30 kg N ha^{-1}	0.23c	0.32c	0.27c	3.18c	4.06c	3.62c	9.11c	9.42c	9.26c	11.78c	12.42c	12.10c
N_3-60 kg N ha^{-1}	0.25b	0.36b	0.30b	3.65b	4.64b	4.15b	10.44b	11.22b	10.83b	14.47b	14.61b	14.54b
N_4-90 kg N ha^{-1}	0.27a	0.39a	0.33a	4.20a	5.57a	4.89a	11.79a	12.48a	12.14a	16.06a	16.29a	16.18a
SEm ±	0.004	0.005	0.003	0.05	0.08	0.04	0.14	0.14	0.14	0.16	0.15	0.15
CD (P = 0.05)	0.01	0.01	0.009	0.16	0.23	0.12	0.42	0.41	0.41	0.46	0.43	0.45
Phosphorus levels												
P_1-0 kg P ha^{-1}	0.20d	0.28d	0.24d	2.39d	2.74d	2.57d	6.90d	6.99d	6.95d	8.59d	9.11d	8.85d
P_2-30 kg P ha^{-1}	0.23c	0.32c	0.28c	3.24c	4.08c	3.66c	9.18c	9.72c	9.45c	12.05c	12.77c	12.41c
P_3-60 kg P ha^{-1}	0.25b	0.36b	0.30b	3.62b	4.80b	4.21b	10.34b	11.01b	10.67b	14.16b	14.33b	14.24b
P_4-90 kg P ha^{-1}	0.26a	0.38a	0.32a	4.03a	5.21a	4.62a	11.34a	12.04a	11.69a	15.66a	15.67a	15.67a
SEm ±	0.004	0.005	0.003	0.05	0.08	0.04	0.14	0.14	0.14	0.16	0.15	0.15
CD (P = 0.05)	0.01	0.01	0.009	0.16	0.23	0.12	0.42	0.41	0.41	0.46	0.43	0.45
N x P												
SEm ±	0.007	0.01	0.006	0.11	0.15	0.08	0.29	0.28	0.29	0.32	0.30	0.31
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Conclusion

Based on the findings from the two-year field investigation, it is concluded that the application of nitrogen and phosphorus significantly enhanced the growth and yield attributes of coriander, with distinct but complementary roles in improving vegetative development, branching, phenological progression, and overall productivity. Nitrogen application up to 60-90 kg N ha^{-1} markedly increased plant height, number of branches, and delayed flowering and maturity, reflecting improved vegetative vigor, while phosphorus application up to 60-90 kg P_2O_5 ha^{-1} enhanced root development, branching, and promoted earlier flowering and maturity. Although plant population remained statistically unaffected by nutrient levels, substantial improvements in key growth parameters highlight the crop's positive responsiveness to balanced fertilization. These results emphasize the importance of adopting site-specific nutrient management strategies in *Inceptisol* soils of Chhattisgarh to optimize coriander productivity, improve resource-use efficiency, and support sustainable spice production systems.

Future Scope

1. **Integration of Nutrient Sources:** Future studies should evaluate the combined use of nitrogen, phosphorus, organic manures, micronutrients, and biofertilizers to improve nutrient-use efficiency and sustain soil fertility in *Inceptisol* soils.
2. **Long-Term Soil Health Monitoring:** Multi-year experiments are needed to understand the long-term impacts of N and P application on soil physicochemical properties, carbon sequestration, and microbial activity.
3. **Precision Nutrient Management:** Adoption of precision farming tools, such as remote sensing, soil nutrient mapping, and decision-support models, may optimize fertilizer recommendations for coriander under diverse field conditions.
4. **Varietal Screening:** Further research should focus on identifying and evaluating nutrient-efficient, high-yielding, and stress-tolerant coriander varieties suitable for different agro-climatic zones of Chhattisgarh.
5. **Physiological and Biochemical Investigations:** Detailed studies on nutrient-regulated flowering

mechanisms, essential oil biosynthesis, and water-nutrient interactions can help refine nutrient management strategies for maximizing productivity and quality.

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