



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(7): 1627-1631
Received: 24-04-2026
Accepted: 28-05-2026

Ajoy Guragai
Ph.D. Scholar, Department of
Plantation Crops and Processing
Uttar Banga Krishi
Viswavidyalaya, Pundibari, Cooch
Behar, West Bengal, India

Himadri Bhattacharjee
Professor, Department of
Plantation Crops and Processing,
Uttar Banga Krishi
Viswavidyalaya, Pundibari, Cooch
Behar, West Bengal, India

PS Meeda
Professor, Department of
Plantation Crops and Processing,
Uttar Banga Krishi
Viswavidyalaya, Pundibari, Cooch
Behar, West Bengal, India

Sanasam Angousana
Ph.D. Scholar, Department of
Pomology and Post Harvest
Technology, Uttar Banga Krishi
Viswavidyalaya, Pundibari, West
Bengal, India

Corresponding Author:
Ajoy Guragai
Ph.D. Scholar, Department of
Plantation Crops and Processing
Uttar Banga Krishi
Viswavidyalaya, Pundibari, Cooch
Behar, West Bengal, India

Effect of nitrogen and phosphorus nutrition on growth, yield and quality of Garlic (*Allium sativum* L.) in Terai region of West Bengal

Ajoy Guragai, Himadri Bhattacharjee, PS Meeda and Sanasam Angousana

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i7u.6172>

Abstract

A field experiment was conducted for two years (2023 - 24 and 2024 - 25) to study the effects of nitrogen (N) and phosphorus (P) nutrition on various growth parameters yield and quality of garlic (*Allium sativum* L.) var. Pundibari local at the instruction-cum-research plots of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal. The experiment was carried out in factorial Randomized Block Design with 3 replications having individual plot size of 2 m². There were 12 treatments consisting of three levels of N (75, 100 and 125 kg ha⁻¹) in the form of urea and four levels of P (40, 50, 60, and 70 kg ha⁻¹) as single super phosphate with a constant dose of potassium (120 kg ha⁻¹). The results revealed that treatment combination (125 kg N and 70 kg P ha⁻¹) was found best and significantly increasing plant height (77.8 cm), leaf length (58.27 cm), number of leaf (9.20), neck girth (13.38 mm), individual fresh bulb weight (30.27 g), bulb length (4.03 cm), bulb breadth (4.44 cm),; clove length (3.38 cm) and number of cloves per bulb (29.15); number of bulbs (31.50) per kg, yield of bulb (2.63 kg) per plot of 2.0 m² with an estimated yield of bulb (13.15 tonnes ha⁻¹). For all the parameters, the analysis of variance indicated a highly significant difference among the treatment combinations of nitrogen and phosphorus. Quality parameters of garlic like total soluble solids (41.38°Brix), ascorbic acid content (14.35 mg) and dry matter accumulation (33.73 g) were also observed to be the best with application of N @ 125 kg ha⁻¹ and P @ 70 kg ha⁻¹. The findings of current research were discussed in view of the fertility management of garlic for the farmers of this region.

Keywords: Garlic, nitrogen, phosphorus, nutrition, yield, quality

Introduction

Garlic (*Allium sativum* L.), a member of family Alliaceae, is the second most widely cultivated *Allium* species after onion. All parts of this plant- cloves, leaves, and stem have been used and consumed either fresh or cooked for health benefits for diseases like diabetes, cancer, ulcer and rheumatism. In addition to its widespread use as a culinary spice and flavouring agent, it is highly valued for its significant medicinal properties, particularly its antimicrobial and anti-carcinogenic effects (Harris *et al.*, 2001) [8]. The crop is a rich source of essential nutrients like sugars, proteins, and dietary fiber, as well as rich in phytochemical profile, containing vital minerals such as phosphorus, potassium, sulphur, iodine, alkaloids, tannins, carotenoids, saponins, flavonoids, steroids and a diverse range of vitamins (Alemu *et al.*, 2016) [12]. India ranks as the world's second-largest producer of garlic, yielding 3503.28 thousand tonnes across 410.79 thousand per hectare of farmland (DADS 2025). Out of the total harvest, India export 43.95 thousand tonnes to other countries, which earn total export revenue of 63.34 million US dollar (SBI 2025). Scaling garlic production has become a strategic priority to satisfy the escalating demand for both domestic consumption and international export. Garlic is cultivated all over India mainly in Gujarat, Odisha, Madhya Pradesh, Rajasthan, Uttar Pradesh and Maharashtra. India serves as a major exporter of various garlic products, including fresh garlic bulbs, dehydrated garlic cloves, garlic powder, and garlic essential oil. In West Bengal, recent years farmers are interested to grow garlic as cash crop during rabi season.

Garlic is a heavy feeder due to its shallow and unbranched root system; its nutrient uptake capacity is lower than other crops. Nitrogen is a key constituent of chlorophyll; it is vital for the process of photosynthesis. Nitrogen levels have been shown to correlate with increased leaf production,

leaf length, and overall plant dry matter. Given its central role in synthesizing proteins and nucleic acids, a consistent nitrogen supply is necessary for optimizing the physiological and structural development of the plant. There is a direct relationship between nitrogen application rates and the growth, quality, and productivity of the crop. Consequently, applying nitrogen in optimal amounts is a fundamental requirement for maximizing garlic yields (Taha *et al.*, 2024) [14]. Phosphorus stimulates early root development and serves as a fundamental component of nucleic acids and bulb formation. Furthermore, it plays a critical role in cell division, enlargement and helps to store energy in the bulbs, while simultaneously enhancing water-use efficiency (Diriba-Shiferaw *et al.*, 2015) [5]. Potassium helps in stress management by controlling opening and closing of stomata and activates different enzyme involved in plant growth. It boosts the plant natural immune system by thickening cell wall, making it fungal spore difficult to penetrate in wall. It promotes strong stem which helps to prevent lodging and making plant stand straight until harvest.

Despite its potential, garlic cultivation in the West Bengal region is hindered by several challenges. Among these, the absence of proper nutrient management practices is a primary factor limiting both overall production and crop productivity. Due to high relative humidity storage of garlic for longer time is not advisable which leads farmers to sell harvest produce as early as possible, it led farmers to receive less value. Farmers often rely on ineffective agronomic practices, such as applying fertilizers without proper doses. These inefficient methods hinder garlic production, leading to the reduced yields and lower crop quality observed in the current research area. For getting optimal yield proper application of fertilizer does is need to be known. Thus, in order to increase crop yield and quality, a systematic study of Suitable fertilizer dose is essential. Therefore, the current study was aimed to determine how different dose of n and p together effect garlic bulb yield and its quality. Based on these facts, the present study was conducted to identify the most suitable dosages of nitrogen (N) and phosphorus (P) fertilizers for garlic cultivars. The objective was to optimize better growth, yield, and quality under the specific agro-climatic conditions of the West Bengal region.

Materials and Methods

The field experiment was conducted during the winter seasons of 2023 – 24 and 2024 – 25 at the Instructional Farm, Department of Plantation Crops and Processing and laboratory work carried out in Faculty of Horticulture, Uttar Banga Krishi Vishwavidyalaya, Pundibari, Cooch Behar.

The experimental site is geographically positioned at 26° 19'86" N latitude and 89° 23'53" E longitude, with an average elevation 43 M above mean sea level. This location falls within the *Tera* agro-climatic zone, which is characterized by high humidity and distinct seasonal variations suitable for rabi crop production. The soil of the experimental plot was sandy loam and acidic in nature, with a pH of 5.26 and electrical conductivity of 0.07 dsm⁻¹. The soil nutrient status was characterized by low levels of available nitrogen (127.63 kg ha⁻¹) and phosphorus (22.74 kg ha⁻¹) and a medium level of available potassium (102.21 kg ha⁻¹). The treatments consisted of three levels of nitrogen as urea (75, 100, 125 kg ha⁻¹), four levels of phosphorus as single super phosphate (40, 50, 60, 70 kg ha⁻¹). Dose of potassium as muriate of potash @ 120 kg are same for all treatments. The plant material used for this experiment was Pundibari local collected and maintained by department of Plantation Crops and Processing since 2021.

The experiment was conducted in factorial randomized block design consist of 12 treatments viz., T₁ (75 kg N + 40 kg P ha⁻¹),

T₂ (75 kg + P 50 kg ha⁻¹), T₃ (N 75 kg +P 60 kg ha⁻¹), T₄ (75 kg N + P 70 kg ha⁻¹), T₅ (100 kg N +40 kg P ha⁻¹), T₆ (100 kg N + 50 kg P ha⁻¹), T₇ (100 kg N + 60 kg P ha⁻¹), T₈ (100 kg N + 70 kg P ha⁻¹), T₉ (125 kg N + 40 kg P ha⁻¹), T₁₀ (125 + 50 kg P ha⁻¹), T₁₁ (125 kg N +60 kg P ha⁻¹) and T₁₂ (125 kg N+70 kg P ha⁻¹) with three replications and the size of individual plot was 2 m². The planting material consisted of healthy outer cloves weighing more than 1g, dibbled at a spacing of 20 cm x 10 cm. From each replication five randomly plants selected to evaluate different growth, yield and quality parameter. observation of all treatment was taken on 30, 60, 90 and 120 days after planting and their mean value were presented in table. Various quality traits were evaluated for each treatment like total soluble solids (TSS) (°Brix), ascorbic acid (mg) and dry matter contents (%), using the methods described below:

Total soluble solid

Total soluble solid were assessed by placing a drop of garlic juice on the prism of a handheld refractometer. Readings were taken against a light source and expressed as °Brix.

Ascorbic acid

To determine ascorbic acid content, fresh and healthy bulbs of uniform size were randomly selected from plants and finely chopped. A 100 g sample from each treatment used for estimation using the 2,6-dichlorophenol indophenol visual titration method. The ascorbic acid content was subsequently expressed in mg 100 g⁻¹ on a fresh weight basis.

Dry matter content (%)

Dry matter content was measured by taking 100 g of homogenate sample and then oven dried it at 65 °C for 48 hours and digital balance was used to measure dry weight. It was calculated by using following formulae (Kumar, 2018) [9]:

$$\text{Dry weight (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

Data Analysis

All the data were analysed using analysis of variance (ANOVA) usings SPSS version 26. Wherever treatment effects were significant at 5% probability level, the means were separated using the Duncan's Multiple Range Test (DMRT) procedures.

Results and Discussion

Growth parameter

The analysis of variance for garlic cultivar Pundibari Local grown for 2023-24 and 2024-25 observed significant differences among various treatments with respect to different growth characteristics like plant height, leaf length, number of leaves, leaf width and collar diameter. This is clear from the Table 1 that maximum plant height (77.88 cm), leaf length (58.27 cm), number of leaves (9.20) and neck girth (13.38 mm) and were recorded with the application of treatment T₁₂ (125 kg N+70 kg P ha⁻¹). Whereas, minimum plant height (70.38 cm), leaf length (49.31 cm), number of leaves (7.64), leaf width (1.07 cm) and collar diameter (10.13 mm) was observed with treatment T₁ (75 kg N+ 40 kg P ha⁻¹). Availability of more nutrient in soil help plants to uptake more nutrients which is essential for healthy growth and development of plant. Application of nitrogen significantly promoted plant height and plays a vital role in stimulating cell division and elongation of plants. This enhancement may be attributed to nitrogen role of an essential constituent of chlorophyll, protoplasm, and various enzymes, as well as its influence on the assimilation and

utilization of phosphorus (Yadav *et al.*, 2022, and Thakur, 2011) [10, 15]. Better photosynthetic activity may have resulted in increased plant height, leaf length and collar diameter. These observations in this study align with established research, supporting previous findings reported by Farooqui *et al.*, 2009 [6].

Yield and yield attributing parameter

The present investigation revealed that yield and yield attributing parameter like length and breadth of bulb, length and breadth of cloves, weight of bulb, clove weight, number of cloves per bulb, number of bulb per kg and weight of bulb per plot were recorded highest in treatment T₁₂ (125 kg N+70 kg P ha⁻¹) followed by T₁₁ (125 kg N+60 kg P ha⁻¹). This is clear from the Table 2 and 3 that maximum length of bulb (4.03 cm), bulb breadth (4.44 cm), clove length (3.38 cm), fresh bulb weight (30.27 g), number of cloves per bulb (29.15), number of bulb per kg (31.50), fresh weight of bulb per plot (2.63 kg) and estimated bulb yield of garlic (13.15 tonnes) ha⁻¹ were obtained in treatments T₁₂ (125 kg N+70 kg P ha⁻¹). The increase in yield of bulb resulting from the combined application of nitrogen and phosphorus may be attributed to the positive interaction between them. This integration enhances photosynthetic activity, the translocation of carbohydrates, and the overall nutrient uptake efficiency of the plants. Phosphorus uptake was increased by nitrogen and helped to promote vegetative growth which led to more production of

leaves and enhance physiological activity resulting in higher bulbs yields. Similar results were reported by Tadila., and Nigusie., 2018 [13].

Quality parameter

The data presented in Table 4 revealed that treatment T₁₂ had significant effect on TSS, ascorbic acid content and dry matter accumulation. The maximum TSS (41.38°B), ascorbic acid content (14.35 mg) and dry matter accumulation (33.73 g) in T₁₂ (125 kg N + 70 kg P ha⁻¹) and minimum content of all the parameter was observed in T₁. The increase in TSS might be due to increase in nutrient availability in soil which led to better uptake of nutrients by plant and higher carbohydrate accumulation in bulb (Silabut *et al.*, 2014) [11]. The results were in consistent with the research conducted by Fismes *et al.*, 2000 [7], Diriba *et al.*, 2015 [5] and Babalashwar *et al.*, 2017 [3]. The increase in ascorbic acid content might be due to optimum nutrient application in soil which increases photosynthetic activity and synthesis of more carbohydrates in plant tissue and it helps to produce more high ascorbic acid production Reddy *et al.*, 2022 and Zhimomi and Deepanshu 2022 [16]. Increasing dry matter content might be the effect of nitrogen and phosphorus that are essential for the accumulation of dry matter Diriba *et al.*, 2015 [5]. Farooque also reported that increase in nitrogen dose led to increase in dry matter content of garlic bulbs.

Table 1: Effect of nitrogen and phosphorus on plant height (cm), leaf length (cm), number of leaves and Neck Girth (mm) in different treatment of garlic at 120 days after planting

Treatment	Plant Height (cm)			Leaf Length (cm)			No of Leaves			Neck Girth (mm)		
	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled
T ₁	62.63 ^{ij}	64.13 ⁱ	63.38 ^{hi}	49.31 ^g	51.14 ^g	50.23 ^{gh}	7.42 ⁱ	7.85 ^h	7.64 ⁱ	10.11 ^h	10.14 ^h	10.13 ^h
T ₂	63.12 ⁱ	64.71 ^h	63.92 ^{hi}	50.23 ^{fg}	52.32 ^f	51.28 ^{fg}	7.51 ^{hi}	7.92 ^g	7.72 ^{gh}	10.18 ^{gh}	10.17 ^g	10.18 ^g
T ₃	63.86 ^{hi}	64.89 ^{gh}	64.38 ^{ghi}	50.98 ^{ef}	52.68 ^{ef}	51.83 ^g	7.57 ^{ghi}	8.06 ^{gh}	7.82 ^g	10.32 ^f	10.36 ^{ef}	10.34 ^{gh}
T ₄	65.45 ^g	67.92 ^{fg}	66.69 ^{fg}	53.66 ^{ef}	55.21 ^{ef}	54.44 ^{ef}	7.68 ^{fgh}	8.11 ^{ef}	7.90 ^{fg}	10.56 ^{ef}	10.65 ^e	10.61 ^g
T ₅	64.84 ^{fg}	66.85 ^f	65.85 ^{fg}	52.18 ^{ef}	53.64 ^{de}	52.91 ^e	7.86 ^{efg}	8.23 ^e	8.05 ^{ef}	10.75 ^e	10.85 ^e	10.80 ^{ef}
T ₆	65.38 ^f	67.38 ^{ef}	66.38 ^f	52.65 ^{de}	54.36 ^d	53.51 ^d	8.11 ^{ef}	8.33 ^d	8.22 ^{de}	11.26 ^d	11.32 ^d	11.29 ^e
T ₇	66.98 ^{de}	67.85 ^{de}	67.42 ^{def}	53.16 ^{cd}	54.85 ^{cd}	54.01 ^{cd}	8.15 ^e	8.45 ^{cd}	8.30 ^{de}	11.58 ^c	11.66 ^{cd}	11.62 ^{de}
T ₈	69.64 ^{de}	74.68 ^d	72.16 ^{de}	55.26 ^{cd}	57.55 ^c	56.41 ^c	8.36 ^d	8.62 ^c	8.49 ^c	11.66 ^c	11.78 ^b	11.72 ^d
T ₉	69.95 ^d	73.54 ^c	71.75 ^d	53.92 ^c	56.12 ^{bc}	55.02 ^{bc}	8.67 ^{cd}	8.75 ^{bc}	8.71 ^{bcd}	12.32 ^b	12.34 ^{bc}	12.33 ^c
T ₁₀	71.32 ^{bc}	74.63 ^b	72.98 ^{bc}	54.16 ^{bc}	56.54 ^{abc}	55.35 ^{ab}	8.86 ^{bc}	9.11 ^b	8.99 ^{ab}	12.54 ^b	12.63 ^{bc}	12.59 ^{bc}
T ₁₁	74.66 ^{ab}	75.66 ^a	75.16 ^b	54.63 ^{ab}	57.32 ^{ab}	55.98 ^{ab}	9.11 ^{ab}	9.14 ^a	9.13 ^a	13.12 ^a	13.16 ^b	13.14 ^{ab}
T ₁₂	76.82 ^a	78.94 ^a	77.88 ^a	57.15 ^a	59.38 ^a	58.27 ^a	9.15 ^a	9.25 ^a	9.20 ^a	13.34 ^a	13.42 ^a	13.38 ^a
SE(m)±	0.71	0.85	0.62	0.82	0.87	0.85	0.15	0.17	0.22	0.02	0.03	0.02
CD(P≤0.05)	1.21	1.16	1.12	1.15	1.12	1.02	0.45	0.65	0.49	0.04	0.05	0.005

Table 2: Effect of nitrogen and phosphorus on bulb length (cm), bulb breadth (cm), clove length (cm) and no clove per bulb in different treatment of garlic at 120 days after planting

Treatment	Bulb length (cm)			Bulb breadth (cm)			Clove length (cm)			No clove per bulb		
	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled
T ₁	3.33 ^g	2.67 ^f	3.00 ^f	3.17 ^h	3.34 ^g	3.25 ^h	2.17 ^j	2.27 ^g	2.22 ^{ij}	18.33 ^f	23.33 ^f	20.83 ⁱ
T ₂	3.37 ^f	2.83 ^e	3.1 ^{ef}	3.47 ^g	3.44 ^{fg}	3.46 ^g	2.38 ⁱ	2.33 ^{ff}	2.36 ^{ff}	22.00 ^f	23.67 ^f	22.83 ^{gh}
T ₃	3.40 ^e	3.13 ^{de}	3.27 ^e	3.57 ^{fg}	3.50 ^f	3.54 ^f	2.65 ^h	2.36 ^e	2.50 ^{eh}	23.33 ^e	24.00 ^{ef}	23.67 ^{fg}
T ₄	3.48 ^{de}	3.20 ^d	3.34 ^{de}	3.77 ^{ef}	3.54 ^f	3.65 ^{ef}	2.80 ^g	2.55 ^{de}	2.67 ^f	23.67 ^e	25.00 ^{ef}	24.33 ^f
T ₅	3.60 ^{cd}	3.23 ^{cd}	3.42 ^{cd}	3.90 ^{de}	3.68 ^e	3.79 ^e	2.90 ^f	2.68 ^{cd}	2.79 ^f	24.33 ^{def}	25.33 ^{def}	24.83 ^{efg}
T ₆	3.63 ^{bc}	3.43 ^c	3.53 ^c	4.03 ^{cd}	3.72 ^{de}	3.88 ^{cd}	3.00 ^f	2.70 ^{cd}	2.85 ^{de}	24.67 ^{de}	26.33 ^{def}	25.50 ^{ef}
T ₇	3.70 ^{bc}	3.47 ^b	3.58 ^{bc}	4.07 ^{bcd}	3.74 ^{de}	3.90 ^{cd}	3.12 ^e	2.83 ^c	2.98 ^{cde}	25.33 ^{cd}	26.67 ^{cde}	26.00 ^{cd}
T ₈	3.73 ^b	3.50 ^b	3.62 ^{bc}	4.20 ^{abc}	3.82 ^{cd}	4.01 ^{bc}	3.25 ^d	2.91 ^c	3.08 ^{bcd}	25.33 ^c	27.00 ^{cd}	26.17 ^{cde}
T ₉	3.76 ^b	3.53 ^{ab}	3.65 ^b	4.27 ^{ab}	3.86 ^c	4.07 ^{abc}	3.33 ^{cd}	2.96 ^{bc}	3.15 ^{bc}	25.67 ^{bc}	28.33 ^{bc}	27.00 ^{bc}
T ₁₀	3.77 ^b	3.57 ^{ab}	3.67 ^b	4.30 ^{ab}	4.34 ^c	4.34 ^{ab}	3.38 ^{bc}	3.11 ^{bc}	3.25 ^{ab}	26.33 ^{bc}	28.67 ^{abc}	27.50 ^{bc}
T ₁₁	3.83 ^{ab}	3.95 ^a	3.73 ^{ab}	4.33 ^a	4.08 ^b	4.19 ^{ab}	3.49 ^{ab}	3.21 ^b	3.33 ^a	26.67 ^{ab}	29.67 ^{ab}	28.17 ^{ab}
T ₁₂	4.10 ^a	3.63 ^a	4.03 ^a	4.40 ^a	4.48 ^a	4.44 ^a	3.55 ^a	3.17 ^a	3.38 ^a	27.30 ^a	31.00 ^a	29.15 ^a
SE(m)±	0.07	0.06	0.5	0.07	0.04	0.05	0.04	0.42	0.27	0.52	0.67	0.36
CD(P≤0.05)	0.21	0.20	0.15	0.21	0.12	0.14	0.11	0.23	0.19	1.53	1.97	1.12

Table 3: Effect of nitrogen and phosphorus on, no. of bulb per kg, bulb weight (g), weight per plot (kg) and yield per hectare (tonnes) in different treatment of garlic at 120 days after planting

Treatment	No. of bulb per kg			Fresh Bulb weight (g)			Bulb Weight (kg/plot)			Bulb Yield (t/hectare)		
	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled
T ₁	43.56 ^a	41.33 ^a	42.45 ^a	21.97 ^f	22.30 ^g	22.13 ^{gh}	2.12 ^f	2.04 ^h	2.08 ^{fg}	10.60 ^{fg}	10.20 ^{gh}	10.40 ^{gh}
T ₂	40.12 ^b	38.65 ^b	39.39 ^{ab}	23.53 ^{ef}	23.27 ^{fg}	23.40 ^g	2.17 ^{ef}	2.11 ^h	2.14 ^f	10.85 ^f	10.55 ^g	10.70 ^{gh}
T ₃	38.41 ^c	37.67 ^{bc}	38.04 ^{bc}	23.60 ^d	23.53 ^f	23.57 ^f	2.25 ^{de}	2.16 ^g	2.21 ^{fg}	11.25 ^e	10.80 ^{fg}	11.03 ^f
T ₄	36.67 ^{cd}	37.15 ^{bcd}	36.91 ^{bcd}	23.73 ^d	25.67 ^e	24.70 ^{ef}	2.31 ^{cd}	2.22 ^{fg}	2.27 ^{ef}	11.55 ^{de}	11.10 ^{fg}	11.33 ^{fg}
T ₅	36.33 ^{de}	36.67 ^{bcd}	36.50 ^{de}	24.27 ^{cd}	25.70 ^e	24.98 ^{de}	2.39 ^{bc}	2.27 ^{ef}	2.33 ^e	11.95 ^d	11.35 ^f	11.65 ^{fg}
T ₆	36.33 ^{de}	36.33 ^{bcd}	36.33 ^{de}	24.50 ^{cd}	26.03 ^{de}	25.27 ^d	2.43 ^{bc}	2.32 ^{de}	2.38 ^{de}	12.15 ^{cd}	11.60 ^e	11.88 ^{de}
T ₇	35.86 ^{def}	35.33 ^{cde}	35.60 ^{def}	24.80 ^c	28.70 ^d	26.75 ^d	2.47 ^{bc}	2.38 ^d	2.43 ^d	12.35 ^{cd}	11.90 ^{de}	12.13 ^{de}
T ₈	35.33 ^{def}	35.21 ^{de}	35.27 ^{def}	25.17 ^c	29.10 ^{cd}	27.13 ^{cd}	2.49 ^{bc}	2.41 ^c	2.45 ^c	12.45 ^c	12.05 ^d	12.25 ^c
T ₉	35.14 ^{ef}	35.67 ^{de}	35.40 ^{ef}	27.43 ^b	29.57 ^{bcd}	28.50 ^{bc}	2.53 ^{bc}	2.46 ^c	2.50 ^{bc}	12.65 ^{bc}	12.30 ^{bc}	12.48 ^{bc}
T ₁₀	34.33 ^{fg}	34.67 ^{ef}	34.50 ^{gh}	27.44 ^{ab}	29.90 ^{bc}	28.67 ^{bc}	2.56 ^{bc}	2.52 ^b	2.54 ^{bc}	12.80 ^{ab}	12.60 ^{bc}	12.70 ^b
T ₁₁	33.12 ^{gh}	34.62 ^f	33.87 ^{hi}	27.47 ^{ab}	30.43 ^{ab}	28.95 ^{ab}	2.59 ^b	2.55 ^b	2.57 ^b	12.95 ^{ab}	12.75 ^b	12.85 ^{ab}
T ₁₂	31.67 ^h	31.33 ^g	31.50 ^{hi}	29.50 ^a	31.03 ^a	30.27 ^a	2.64 ^a	2.59 ^a	2.63 ^a	13.20 ^a	13.10 ^a	13.15 ^a
SE(m) ±	0.46	0.66	0.41	0.33	0.34	0.27	0.08	0.05	0.06	0.25	0.16	0.19
CD(P≤0.05)	1.54	1.96	1.12	0.97	1.01	0.82	0.23	0.14	0.12	0.57	0.35	0.43

Table 4: Effect of nitrogen and phosphorus on TSS (°Brix), Ascorbic acid (mg) and dry matter content (%) in different treatment of garlic at 120 days after planting.

Treatment	TSS (°Brix)			Ascorbic acid (mg 100g ⁻¹)			Dry matter content (%)		
	2024	2025	Pooled	2024	2025	Pooled	2024	2025	Pooled
T ₁	29.20 ⁱ	35.30 ⁱ	32.25 ^{hi}	8.01 ^g	10.37 ^h	9.19 ^{gh}	26.87 ^g	30.17 ^h	28.52 ^j
T ₂	32.10 ^g	35.67 ^{gh}	33.88 ^g	9.98 ^f	10.67 ^{gh}	10.33 ^{fg}	29.60 ^f	30.43 ^{gh}	30.02 ^{hi}
T ₃	32.67 ^g	36.47 ^g	34.57 ^{fg}	10.8 ^{8e}	10.90 ^{fg}	10.89 ^{ef}	30.37 ^{ef}	30.53 ^{fgh}	30.45 ^{gh}
T ₄	33.13 ^{hg}	36.90 ^f	35.02 ^{efg}	10.98 ^{de}	11.27 ^{ef}	11.12 ^{efg}	30.37 ^{ef}	31.00 ^{efg}	30.68 ^{gh}
T ₅	34.03 ^{ef}	37.77 ^f	35.90 ^e	11.71 ^{de}	11.40 ^e	11.56 ^{ef}	31.07 ^{de}	31.37 ^{def}	31.22 ^{def}
T ₆	35.10 ^{de}	37.93 ^{de}	36.52 ^{cd}	12.01 ^{cd}	11.47 ^e	11.74 ^e	31.37 ^{cde}	31.50 ^{def}	31.43 ^{de}
T ₇	35.80 ^{cd}	39.63 ^d	37.72 ^{cd}	12.16 ^{cd}	11.87 ^d	12.01 ^{cd}	31.90 ^{cd}	32.03 ^{cde}	31.97 ^{cd}
T ₈	36.67 ^{bc}	39.73 ^{cd}	38.20 ^{bc}	13.21 ^b	12.10 ^d	12.66 ^{cd}	32.43 ^{cd}	32.10 ^{cd}	32.27 ^{cd}
T ₉	37.17 ^{bc}	40.40 ^c	38.78 ^{bcd}	13.41 ^b	12.57 ^c	12.99 ^{bc}	31.93 ^{bc}	32.23 ^{bcd}	32.08 ^{bc}
T ₁₀	37.50 ^{ab}	40.93 ^{bc}	39.22 ^{ab}	13.68 ^b	12.73 ^{bc}	13.21 ^{abc}	33.17 ^{ab}	32.93 ^{abc}	33.05 ^{ab}
T ₁₁	37.93 ^{ab}	42.70 ^b	40.32 ^a	14.21 ^{ab}	13.03 ^b	13.62 ^b	33.20 ^b	33.23 ^{ab}	33.22 ^b
T ₁₂	38.43 ^a	44.33 ^a	41.38 ^a	15.19 ^a	13.50 ^a	14.35 ^a	33.63 ^a	33.83 ^a	33.73 ^a
SE(m)±	0.42	0.44	0.42	0.33	0.17	0.25	0.35	0.34	0.33
CD(P≤0.05)	1.24	1.33	1.28	0.98	0.50	0.76	1.04	1.01	1.03

Conclusion

The results shows that all of the garlic growth, yield and quality characteristics were significantly affected by the application of different levels of nitrogen and phosphorus fertilizer nutrient combination. From the comparative study of different treatment combinations of nitrogen and phosphorus, it can be concluded that treatment T₁₂ (recommended dose of NP125:70 kg ha⁻¹) was found for increase plant growth, bulb weight, bulb diameter, bulb yield, TSS, Ascorbic acid and Dry matter content. Therefore, recommendation of NP fertilizer @ NP125:70 Kg ha⁻¹ as fertilizer doses for cultivation of garlic in *Terai* region of West Bengal.

Acknowledgements

The author sincerely acknowledges the Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal for providing research field, laboratory and technical support and also to SVMCM for financial support to carry out the current research.

Conflict of Interest: None.

References

- Association of Official Analytical Chemists (AOAC). Official methods of analysis. 12th ed. Washington (DC): AOAC; 1975.
- Alemu D, Nigussie D, Fikreyohannes G. Effects of vermicompost and inorganic NP fertilizers on growth, yield and quality of garlic (*Allium sativum* L.). J Biol Agric Healthc. 2016;6(3):1-8.
- Babaleswar SB, Koppad SR, Math KK, Dharmatti R. Influence of sulphur on growth and yield of garlic (*Allium sativum* L.). J Pharmacogn Phytochem. 2017;6(5):450-452.
- Directorate of Arecanut and Spices Development (DASD). Ministry of Agriculture and Farmers Welfare, Government of India; 2021.
- Diriba-Shiferaw G, Nigussie-Dechassa R, Woldetsadik K, Abor G, Sharma JJ. Effect of nitrogen, phosphorus, and sulphur fertilizers on growth, yield, and economic returns of garlic (*Allium sativum* L.). Sci Technol Arts Res J. 2015;4(2):10-22.
- Farooqui MA, Naruka IS, Rathore SS, Singh PP, Shaktawat RPS. Effect of nitrogen and sulphur levels on growth and yield of garlic (*Allium sativum* L.). Asian J Food Agro-Ind. 2009;Special Issue:S18-S23.
- Fismes J, Vong PC, Gucker A, Frossard E. Influence of sulfur on apparent N-use efficiency, yield and quality of oilseed rape (*Brassica napus* L.) grown on a calcareous soil. Eur J Agron. 2000;12:127-141.
- Harris JC, Cottrell SL, Plummer S, Lloyd D. Antimicrobial properties of *Allium sativum* L. (garlic). Appl Microbiol Biotechnol. 2001;57(3):282-286.
- Kumar P, Aulakh S. Effect of spacing and nitrogenous fertilizer on growth and yield parameters of garlic. Int J Chem Stud. 2018;6(4):356-359.
- Yadav SS, Asanti K, Sharma A, Kamathker A. Combined

- impact of major and micronutrients on yield, quality and economics of garlic (*Allium sativum* L.). *Pharma Innov.* 2022;11(4):706-708.
11. Silabut IN, Naruka IS, Shaktawat RPS, Verma KS, Seyie A. Response of garlic cultivars to irrigation levels. *Indian J Hortic.* 2014;71(3):354-359.
 12. Spices Board India. Major item-wise and country-wise export of spices from India during 2024-25. Ministry of Commerce and Industry, Government of India; 2025.
 13. Tadila G, Nigusie D. Effect of manure and nitrogen rates on growth and yield of garlic (*Allium sativum* L.) at Haramaya, Eastern Ethiopia. *J Hortic For.* 2018;10(9):135-142.
 14. Taha NM, Bukhari NA, Hatamleh AA, Górnik K, Sabah SS, Hashem FA, *et al.* An attempt to reduce nitrogen fertilization levels and their impact on the growth and productivity of garlic (*Allium sativum* L.) under different planting dates. *Horticulturae.* 2024;10(12):1377.
 15. Thakur BS. Effect of planting date, nitrogen and phosphorus levels on marketable bulb yield in garlic (*Allium sativum* L.) under mid hill conditions of Himachal Pradesh. *J Hill Agric.* 2011;2(1):42-46.
 16. Zhimomi, Deepanshu. Effect of micronutrients on growth, yield and quality of garlic (*Allium sativum* L.). *Pharma Innov J.* 2022;11(1):249-251.