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EFFECT OF NITROGEN AND PHOSPHORUS ON GROWTH AND YIELD OF MUSTARD (*BRASSICA JUNCEA* L.)

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ABSTRACT

A field experiment was conducted during *Rabi* season 2024-25 in Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, to study the effect of nitrogen and phosphorus on growth and yield of mustard (*Brassica juncea* L.). The treatment consisted of three levels of nitrogen (70, 80 and 90 kg/ha) and phosphorus (20, 40 and 60 kg/ha). The experiment was laid out in Randomized Block Design (RBD) with nine treatments, replicated thrice. The application of treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus) recorded significantly higher plant height (136.51 cm), number of branches/plant (15.93) and plant dry weight (24.24 g) and higher yield attributes namely a greater number of siliquae/plant (220.07), number of seeds/ siliquae (17.33), test weight (5.74 g) seed yield (1874.33 kg/ha) and stover yield (3843.67 kg/ha). The maximum benefit cost ratio (1.72) was also recorded in T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus) and was found to be productive as well as economically feasible.

Key words : Growth, Mustard, Nitrogen, Phosphorus, Yield

Introduction

Indian mustard (*Brassica juncea* L.) is a member of the Brassicaceae family, is commonly known as mustard. Mustard oil is used in cooking, medicine and industry. Mustard seed contains vitamins and minerals and is a good source of omega-3 fatty acids (USDA National Nutrient Database, 2012). Mustard is the second most important oil seed crop, contributing nearly 25-30% of the total oil seed production in the country. Oil seeds, the second largest agricultural commodity after cereals in India, play a significant role in India's agrarian economy, sharing 14% of the gross cropped area and accounting for nearly 1.5% of the gross national production and 8% of the value of all agricultural products. A range of oilseed crops *viz.* groundnut, rapeseed and mustard, soybean, sesame, sunflower, safflower and niger (edible) and linseed and castor (non-edible) are cultivated in the country. In *Brassica sp.* mustard is important edible oil next to groundnut. Its oil is used often for cooking and rapeseed mustard also valued for vegetables, condiments,

fodder and medicinal purposes for remedy against stomach and skin disease etc. (Solanki *et al.*, 2018).

Indian mustard is an important *rabi* crop of eastern India comprising Uttar Pradesh, Bihar, West Bengal and Assam. India occupies the third position in mustard production in world after China and Canada. The area under rapeseed-mustard in India is 9.80 mha, production is 11.4 mt and productivity is 1179 kg/ha (Agricultural Statistics at a Glance, 2021-22). The major rapeseed-mustard growing states are Rajasthan, Madhya Pradesh, Uttar Pradesh, Haryana, West Bengal; which account for 82% of the total rapeseed-mustard area and 85% of the total production of the country. In India, during 2019-20, the mustard crop had production of 8.23 mt from an area of 7.50 million hectares with an average productivity of 1138 kg/ha (Solanki *et al.*, 2018).

Rapeseed-mustard is currently India's third most important oilseed crop, trailing only groundnut and soybean. India is the world's largest producer, consumer and importer of oilseeds. Indian mustard, one of nine major

oilseeds grown in India, is an important winter season Rabi crop. The gap between rapeseed-mustard production and demand is widening, so production must be increased to achieve self-sufficiency.

Nitrogen is a crucial nutrient for mustard cultivation, offering several benefits that enhance growth, yield and quality of crop. Nitrogen is a key component of chlorophyll, which is essential for photosynthesis. Adequate nitrogen supply boosts the vegetative growth of mustard plants, leading to larger and healthier leaves that can efficiently capture sunlight. Nitrogen supports the development of flowers and seeds in mustard plants. A sufficient nitrogen supply leads to a higher number of pods per plant and greater number of seeds per pod which directly increase the overall seed yield. The quality of mustard seed is often judged by their oil content. Nitrogen fertilization can enhance the oil content of the seeds making the crop more valuable. Nitrogen is a major component of amino acid the building blocks of proteins. Mustard seeds with adequate nitrogen supply have a higher protein content, which is beneficial for both nutritional value and industrial uses. Nitrogen also promotes robust roots growth in mustard plants, which improves nutrient and water uptake from the soil, further supporting overall plant health (Sharma *et al.*, 2020).

Phosphorus is a vital nutrient for mustard cultivation, playing a significant role in various physiological processes that contributes to the growth, development and the yield of the crop. Phosphorus is crucial for the development of a strong root system. In mustard plants, a well-developed root system enhances the plant's ability to absorb water and nutrients, which is essential robust growth specially in the early stages. Phosphorus is the key to energy transfer and storage in plants, which is critical during the flowering and seed formation stages. Adequate phosphorus ensures better flowering development and more efficient seed setting, leading to higher seed yields. It contributes to the synthesis of oils in mustard seeds. by ensuring and adequate supply of phosphorus, the oil content in mustard seeds can be optimized increasing the economic value of the crop. It is a component of ATP, the energy currency of the plant cells this make it essential for photosynthesis and the overall energy management within the mustard plants promoting healthy and vigorous growth (Tyagi *et al.*, 2022).

In view of the significant importance of Indian mustard in India's edible oil economy and the widening gap between its production and demand, there is a pressing need to enhance its productivity through improved nutrient management practices. Among the essential nutrients,

nitrogen and phosphorus play a pivotal role in influencing growth, yield attributes, seed quality and economic returns of mustard. However, imbalanced or sub-optimal application of these nutrients often limits crop performance under field conditions. Therefore, a systematic evaluation of different levels and combinations of nitrogen and phosphorus is essential to identify optimal nutrient management strategies for maximizing yield and profitability. Keeping these aspects in view, the present investigation was undertaken to study the effect of nitrogen and phosphorus on growth, yield and economics of Indian mustard (*Brassica juncea* L.) during the rabi season.

Materials and Methods

The experiment was conducted during the *Rabi* season of 2023 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The experimental site is located at 25.43° N latitude and 81.84° E longitude, at an altitude of 98 m above mean sea level. The farm is situated on the right bank of the river Yamuna, along the Prayagraj-Rewa Road, approximately 5 km away from Prayagraj city. The region falls under a subtropical, semi-arid climatic zone, characterized by wide seasonal variations in temperature, with hot summers and cold winters. The soil of the experimental field was sandy loam in texture with a nearly neutral soil reaction (pH 7.8). It was low in organic carbon (0.72%), available nitrogen (178.48 kg/ha), available phosphorus (27.80 kg/ha), and available potassium (233.34 kg/ha).

The experiment was laid out in a Randomized Block Design (RBD) with three replications and nine treatment combinations. The treatments involved three levels of nitrogen (70 kg/ha, 80 kg/ha and 90 kg/ha) combined with three levels of phosphorus (20 kg/ha, 40 kg/ha and 60 kg/ha), randomly allocated within each replication. The treatments were, T₁ (70 kg/ha nitrogen + 20 kg/ha phosphorus), T₂ (70 kg/ha nitrogen + 40 kg/ha phosphorus), T₃ (70 kg/ha nitrogen + 60 kg/ha phosphorus), T₄ (80 kg/ha nitrogen + 20 kg/ha phosphorus), T₅ (80 kg/ha nitrogen + 40 kg/ha phosphorus), T₆ (80 kg/ha nitrogen + 60 kg/ha phosphorus), T₇ (90 kg/ha nitrogen + 20 kg/ha phosphorus), T₈ (90 kg/ha nitrogen + 40 kg/ha phosphorus) and T₉ (90 kg/ha nitrogen + 60 kg/ha phosphorus).

Observations on crop growth and yield parameters were recorded at different stages of crop growth. Pre-harvest observations were taken at 20, 40, 60 and 80 days after sowing (DAS), which included plant height,

number of branches per plant, plant dry weight, crop growth rate (CGR), and relative growth rate (RGR). Post-harvest observations comprised yield and yield-attributing characters such as number of siliquae per plant, number of seeds per siliqua, test weight, seed yield, stover yield, and harvest index. Economic analysis of the treatments was carried out by computing cost of cultivation, gross return, net return, and benefit–cost (B:C) ratio on a per hectare basis.

Results and Discussion

Pre-harvest observations

Plant height (cm)

The plant height of mustard was recorded at 20, 40, 60 and 80 DAS differed significantly as influenced by nitrogen and phosphorus levels (Table 1). At 20 DAS, higher plant height (9.36 cm) was recorded in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus), although the differences among the treatments were non-significant. At 40 DAS, higher plant height (20.62 cm) was recorded in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus). However, the treatment T₁ (70 kg/ha Nitrogen + 20 kg/ha Phosphorus), treatment T₄ (80 kg/ha Nitrogen + 20 kg/ha Phosphorus), treatment T₆ (80 kg/ha Nitrogen + 60 kg/ha Phosphorus) were found to be statistically at par with treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus). At 60 DAS, higher plant height (109.18 cm) was recorded in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus), However the treatment T₁ (70 kg/ha Nitrogen + 20 kg/ha Phosphorus), treatment T₂ (70 kg/ha Nitrogen + 40 kg/ha Phosphorus), treatment T₄ (80 kg/ha Nitrogen + 20 kg/ha Phosphorus), treatment T₆ (80 kg/ha Nitrogen + 60 kg/ha Phosphorus) were found to be statistically at

par with treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus). At 80 DAS, higher plant height (136.51 cm) was recorded in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus), however the treatment T₈ (90 kg/ha Nitrogen + 40 kg/ha Phosphorus) were found to be statistically at par with treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus). The application of Nitrogen (80 kg/ha) and Phosphorus (40 kg/ha) were found beneficial for early well developed and matured growth of mustard plants. These results agree with the results obtained by Mishra *et al.* (2010), Singh and Thenua (2016), Khatun (2021) and Khan *et al.* (2019).

Number of branches/plants

The number of branches/plants of mustard was recorded at 40, 60 and 80 DAS differed significantly as influenced by nitrogen and phosphorus levels (Table 2). At 40 DAS, higher number of branches/plants (6.13) was recorded in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus), however the treatment T₂ (70 kg/ha Nitrogen + 40 kg/ha Phosphorus) were found to be statistically at par with treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus). At 60 DAS, higher number of branches/plants (13.00) was recorded in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus). However the treatment T₂ (70 kg/ha Nitrogen + 40 kg/ha Phosphorus), treatment T₃ (70 kg/ha Nitrogen + 60 kg/ha Phosphorus), treatment T₄ (80 kg/ha Nitrogen + 20 kg/ha Phosphorus), treatment T₆ (80 kg/ha Nitrogen + 60 kg/ha Phosphorus), treatment T₇ (90 kg/ha Nitrogen + 20 kg/ha Phosphorus) were found to be statistically at par with treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus). At 80 DAS, higher number of branches/plants (15.93) was recorded in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus), however the treatment

Table 1 : Effect of nitrogen and phosphorus on plant height of mustard.

S. no.	Treatment Combinations	Plant height (cm)			
		20 DAS	40 DAS	60 DAS	80 DAS
1.	T ₁ - 70 kg/ha Nitrogen + 20 kg/ha Phosphorus	8.54	20.30	106.76	117.93
2.	T ₂ - 70 kg/ha Nitrogen + 40 kg/ha Phosphorus	8.38	18.50	105.17	125.07
3.	T ₃ - 70 kg/ha Nitrogen + 60 kg/ha Phosphorus	9.10	17.78	88.61	123.92
4.	T ₄ - 80 kg/ha Nitrogen + 20 kg/ha Phosphorus	9.30	20.44	108.10	130.70
5.	T ₅ - 80 kg/ha Nitrogen + 40 kg/ha Phosphorus	9.36	20.62	109.18	136.51
6.	T ₆ - 80 kg/ha Nitrogen + 60 kg/ha Phosphorus	8.86	20.07	107.98	126.07
7.	T ₇ - 90 kg/ha Nitrogen + 20 kg/ha Phosphorus	8.26	16.84	90.88	128.08
8.	T ₈ - 90 kg/ha Nitrogen + 40 kg/ha Phosphorus	8.54	16.94	93.67	135.19
9.	T ₉ - 90 kg/ha Nitrogen + 60 kg/ha Phosphorus	8.49	17.25	92.11	111.30
	F-test	NS	S	S	S
	SEm (±)	0.60	0.54	1.47	1.87
	CD (p=0.05)	1.79	1.61	4.40	5.60

Table 2 : Effect of nitrogen and phosphorus on number of branches/plants of mustard.

S. no.	Treatment Combinations	Number of branches/plants		
		40 DAS	60 DAS	80 DAS
1.	T ₁ - 70 kg/ha Nitrogen + 20 kg/ha Phosphorus	5.47	11.53	13.93
2.	T ₂ - 70 kg/ha Nitrogen + 40 kg/ha Phosphorus	5.87	12.27	13.93
3.	T ₃ - 70 kg/ha Nitrogen + 60 kg/ha Phosphorus	5.40	12.80	14.73
4.	T ₄ - 80 kg/ha Nitrogen + 20 kg/ha Phosphorus	4.93	12.53	15.67
5.	T ₅ - 80 kg/ha Nitrogen + 40 kg/ha Phosphorus	6.13	13.00	15.93
6.	T ₆ - 80 kg/ha Nitrogen + 60 kg/ha Phosphorus	5.07	12.27	14.93
7.	T ₇ - 90 kg/ha Nitrogen + 20 kg/ha Phosphorus	5.33	12.60	15.67
8.	T ₈ - 90 kg/ha Nitrogen + 40 kg/ha Phosphorus	5.40	10.73	15.00
9.	T ₉ - 90 kg/ha Nitrogen + 60 kg/ha Phosphorus	4.53	12.40	13.73
	F-test	S	S	S
	SEm (±)	0.18	0.34	0.38
	CD (p=0.05)	0.53	1.01	1.15

Table 3 : Effect of nitrogen and phosphorus on plant dry weight of mustard.

S. no.	Treatment Combinations	Plant dry weight (g)			
		20 DAS	40 DAS	60 DAS	80 DAS
1.	T ₁ - 70 kg/ha Nitrogen + 20 kg/ha Phosphorus	1.53	3.50	12.21	21.32
2.	T ₂ - 70 kg/ha Nitrogen + 40 kg/ha Phosphorus	1.39	3.67	12.16	21.06
3.	T ₃ - 70 kg/ha Nitrogen + 60 kg/ha Phosphorus	1.41	3.74	14.08	24.15
4.	T ₄ - 80 kg/ha Nitrogen + 20 kg/ha Phosphorus	1.85	3.78	14.32	23.32
5.	T ₅ - 80 kg/ha Nitrogen + 40 kg/ha Phosphorus	2.04	3.97	15.40	24.24
6.	T ₆ - 80 kg/ha Nitrogen + 60 kg/ha Phosphorus	1.32	3.65	14.12	24.19
7.	T ₇ - 90 kg/ha Nitrogen + 20 kg/ha Phosphorus	1.93	3.52	13.46	22.64
8.	T ₈ - 90 kg/ha Nitrogen + 40 kg/ha Phosphorus	1.95	3.53	12.59	21.00
9.	T ₉ - 90 kg/ha Nitrogen + 60 kg/ha Phosphorus	1.64	3.57	12.06	23.46
	F-test	NS	NS	S	S
	SEm (±)	0.02	0.07	0.42	0.15
	CD (p=0.05)	0.06	0.22	1.25	0.44

T₄ (80 kg/ha Nitrogen + 20 kg/ha Phosphorus), treatment T₆ (80 kg/ha Nitrogen + 60 kg/ha Phosphorus), treatment T₇ (90 kg/ha Nitrogen + 20 kg/ha Phosphorus), treatment T₈ (90 kg/ha Nitrogen + 40 kg/ha Phosphorus) were found to be statistically at par with treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus). These findings corroborated the earlier results obtained by Mishra *et al.* (2010), Kumar *et al.* (2017), Raghuvanshi *et al.* (2018), Gautham *et al.* (2019). The application of nitrogen and phosphorus fertilization significantly increased the number of branches per plant in mustard, with higher doses resulting in greater branching and enhanced vegetative architecture, as similarly reported by Bankoti *et al.* (2021) and Nath *et al.* (2018).

Plant dry weight (g)

The plant dry weight of mustard was recorded at 20, 40, 60 and 80 DAS differed significantly as influenced

by nitrogen and phosphorus levels (Table 3). At 20 DAS, higher plant dry weight (2.04 g) was recorded in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus), although the differences among the treatments were non-significant. At 40 DAS, higher plant dry weight (3.97 g) was recorded in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus), although the differences among the treatments were non-significant. At 60 DAS, higher plant dry weight (15.40 g) was recorded in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus), treatment T₄ (80 kg/ha Nitrogen + 20 kg/ha Phosphorus) were found to be statistically at par with treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus). At 80 DAS, higher plant dry weight (24.24 g) was recorded in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus), treatment T₃ (70 kg/ha Nitrogen + 60 kg/ha Phosphorus), treatment T₆ (80 kg/ha Nitrogen + 60 kg/ha Phosphorus) were found

Table 4 : Effect of nitrogen and phosphorus on crop growth rate of mustard.

S. no.	Treatment Combinations	Crop growth rate (g/m ² /day)		
		20-40 DAS	40-60 DAS	60-80 DAS
1.	T ₁ - 70 kg/ha Nitrogen + 20 kg/ha Phosphorus	3.29	14.52	14.69
2.	T ₂ - 70 kg/ha Nitrogen + 40 kg/ha Phosphorus	3.80	14.14	17.36
3.	T ₃ - 70 kg/ha Nitrogen + 60 kg/ha Phosphorus	3.89	17.23	16.45
4.	T ₄ - 80 kg/ha Nitrogen + 20 kg/ha Phosphorus	3.22	17.57	14.56
5.	T ₅ - 80 kg/ha Nitrogen + 40 kg/ha Phosphorus	3.23	19.04	11.42
6.	T ₆ - 80 kg/ha Nitrogen + 60 kg/ha Phosphorus	3.89	17.45	18.61
7.	T ₇ - 90 kg/ha Nitrogen + 20 kg/ha Phosphorus	2.65	16.56	15.30
8.	T ₈ - 90 kg/ha Nitrogen + 40 kg/ha Phosphorus	2.64	15.10	12.99
9.	T ₉ - 90 kg/ha Nitrogen + 60 kg/ha Phosphorus	3.22	14.15	20.30
	F-test	S	S	S
	SEm (±)	0.11	0.70	0.59
	CD (p=0.05)	0.34	2.10	1.76

Table 5 : Effect of nitrogen and phosphorus on relative crop growth rate of mustard.

S. no.	Treatment Combinations	Relative crop growth rate (g/g/day)		
		20-40 DAS	40-60 DAS	60-80 DAS
1.	T ₁ - 70 kg/ha Nitrogen + 20 kg/ha Phosphorus	0.051	0.040	0.026
2.	T ₂ - 70 kg/ha Nitrogen + 40 kg/ha Phosphorus	0.053	0.041	0.025
3.	T ₃ - 70 kg/ha Nitrogen + 60 kg/ha Phosphorus	0.052	0.038	0.026
4.	T ₄ - 80 kg/ha Nitrogen + 20 kg/ha Phosphorus	0.061	0.033	0.025
5.	T ₅ - 80 kg/ha Nitrogen + 40 kg/ha Phosphorus	0.062	0.035	0.030
6.	T ₆ - 80 kg/ha Nitrogen + 60 kg/ha Phosphorus	0.049	0.040	0.023
7.	T ₇ - 90 kg/ha Nitrogen + 20 kg/ha Phosphorus	0.048	0.037	0.030
8.	T ₈ - 90 kg/ha Nitrogen + 40 kg/ha Phosphorus	0.056	0.039	0.026
9.	T ₉ - 90 kg/ha Nitrogen + 60 kg/ha Phosphorus	0.056	0.038	0.027
	F-test	NS	NS	NS
	SEm (±)	0.0024	0.0020	0.0021
	CD (p=0.05)	0.01	0.01	0.01

to be statistically at par with treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus). Singh *et al.* (2000) found that combined N–P application significantly boosted vegetative growth, including dry matter accumulation, in mustard. Similarly, the application of phosphorus at higher rates has been shown to enhance plant height, number of branches and dry weight in mustard, as reported by Khatkar *et al.* (2019). These findings underscore the synergistic role of balanced nitrogen and phosphorus supply in stimulating cell division, elongation and biomass accumulation, resulting in increased dry weight over time.

Crop Growth Rate (g/m²/day)

The crop growth rate of mustard was recorded at 20-40, 40-60 and 60-80 DAS differed significantly as influenced by nitrogen and phosphorus levels (Table 4). At 20-40 DAS, higher crop growth rate (3.89 g/m²/day) was recorded in treatment T₃ (70 kg/ha Nitrogen + 60

kg/ha Phosphorus) & T₆ (80 kg/ha Nitrogen + 60 kg/ha Phosphorus), however the treatment T₂ (70 kg/ha Nitrogen + 40 kg/ha Phosphorus), were found to be statistically at par with treatment T₃ (70 kg/ha Nitrogen + 60 kg/ha Phosphorus) & T₆ (80 kg/ha Nitrogen + 60 kg/ha Phosphorus). At 40-60 DAS, higher crop growth rate (19.04 g/m²/day) was recorded in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus) however the treatment T₃ (70 kg/ha Nitrogen + 60 kg/ha Phosphorus), treatment T₄ (80 kg/ha Nitrogen + 20 kg/ha Phosphorus), treatment T₆ (80 kg/ha Nitrogen + 60 kg/ha Phosphorus) were found to be statistically at par with treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus). At 60-80 DAS, higher crop growth rate (20.30 g/m²/day) was recorded in treatment T₉ (90 kg/ha Nitrogen + 60 kg/ha Phosphorus) however the treatment T₆ (80 kg/ha Nitrogen + 60 kg/ha Phosphorus) were found to be statistically at

Table 6 : Effect of nitrogen and phosphorus on yield attributes of mustard.

S. no.	Treatment Combinations	Number of Siliqua /Plant	Number of Seeds/ Siliqua	Test weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
1.	T ₁ - 70 kg/ha Nitrogen + 20 kg/ha Phosphorus	215.00	15.87	5.33	1743.33	3580.00	32.76
2.	T ₂ - 70 kg/ha Nitrogen + 40 kg/ha Phosphorus	204.93	16.87	5.20	1740.00	3632.67	32.39
3.	T ₃ - 70 kg/ha Nitrogen + 60 kg/ha Phosphorus	205.07	17.13	5.31	1680.00	3479.33	32.57
4.	T ₄ - 80 kg/ha Nitrogen + 20 kg/ha Phosphorus	183.13	16.73	4.93	1453.33	3595.67	28.82
5.	T ₅ - 80 kg/ha Nitrogen + 40 kg/ha Phosphorus	220.07	17.33	5.74	1874.33	3843.67	32.80
6.	T ₆ - 80 kg/ha Nitrogen + 60 kg/ha Phosphorus	185.33	16.67	5.44	1530.00	3781.33	28.80
7.	T ₇ - 90 kg/ha Nitrogen + 20 kg/ha Phosphorus	206.87	14.67	4.86	1763.33	3436.67	33.90
8.	T ₈ - 90 kg/ha Nitrogen + 40 kg/ha Phosphorus	196.33	17.07	4.87	1640.00	3670.00	30.90
9.	T ₉ - 90 kg/ha Nitrogen + 60 kg/ha Phosphorus	210.47	16.93	5.44	1800.33	3802.00	32.14
	F-test	S	S	S	S	S	S
	SEm(±)	4.77	0.26	0.13	27.13	78.97	0.51
	CD(p=0.05)	14.30	0.77	0.38	81.34	236.74	1.52

par with treatment T₉ (80 kg/ha Nitrogen + 60 kg/ha Phosphorus).

Relative Growth Rate (g/g/day)

The relative growth rate of mustard was recorded at 20-40, 40-60 and 60-80 DAS differed significantly as influenced by nitrogen and phosphorus levels (Table 5). At 20-40 DAS, higher relative growth rate (0.062 g/g/day) was recorded in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus), although the differences among the treatments were non-significant. At 40-60 DAS, higher relative growth rate (0.041 g/g/day) was recorded in treatment T₂ (70 kg/ha Nitrogen + 40 kg/ha Phosphorus), although the differences among the treatments were non-significant. At 60-80 DAS, higher relative growth rate (0.030 g/g/day) was recorded in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus), although the differences among the treatments were non-significant.

Post-harvest observations

In Table 6 data pertaining to post-harvest observations of mustard as influenced by nitrogen and phosphorus levels has been exhibited.

Number of siliqua/plants

The significantly higher number of siliqua/plant (220.07) were observed in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus) however the treatment 1 (70 kg/ha nitrogen + 20 kg/ha phosphorus), treatment 7 (90 kg/ha nitrogen + 20 kg/ha phosphorus), treatment 9 (90 kg/ha nitrogen + 60 kg/ha phosphorus) were found to be statistically at par with treatment 5 (80 kg/ha Nitrogen + 40 kg/ha Phosphorus).

Number of seeds/siliquae

The significantly higher number of seeds/siliqua

(17.33) was observed in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus) however the treatment 2 (70 kg/ha nitrogen + 40 kg/ha phosphorus), treatment 3 (70 kg/ha nitrogen + 60 kg/ha phosphorus), treatment 4 (80 kg/ha nitrogen + 20 kg/ha phosphorus), treatment 6 (80 kg/ha nitrogen + 60 kg/ha phosphorus), treatment 8 (90 kg/ha nitrogen + 40 kg/ha phosphorus), treatment 9 (90 kg/ha nitrogen + 60 kg/ha phosphorus) were found to be statistically at par with treatment 5 (80 kg/ha Nitrogen + 40 kg/ha Phosphorus).

Test weight (g)

The significantly higher test weight (5.74 g) was observed in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus) however the treatment 6 (80 kg/ha nitrogen + 60 kg/ha phosphorus), treatment 9 (90 kg/ha nitrogen + 60 kg/ha phosphorus) were found to be statistically at par with treatment 5 (80 kg/ha Nitrogen + 40 kg/ha Phosphorus).

Seed yield (kg/ha)

The significantly higher seed yield (1874.33 kg/ha) was observed in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus) however the treatment 9 (90 kg/ha nitrogen + 60 kg/ha phosphorus) were found to be statistically at par with treatment 5 (80 kg/ha Nitrogen + 40 kg/ha Phosphorus).

Stover yield (kg/ha)

The significantly higher seed yield (3843.67 kg/ha) was observed in treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus) however the treatment 2 (70 kg/ha nitrogen + 40 kg/ha phosphorus), treatment 6 (80 kg/ha nitrogen + 60 kg/ha phosphorus), treatment 8 (80 kg/ha nitrogen + 40 kg/ha phosphorus), treatment 9 (90 kg/ha

Table 7 : Effect of nitrogen and phosphorus on economics of mustard.

S. no.	Treatment Combinations	Economics			
		Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	Benefit Cost Ratio
1.	T ₁ - 70 kg/ha Nitrogen + 20 kg/ha Phosphorus	40192.32	104600.00	64407.68	1.60
2.	T ₂ - 70 kg/ha Nitrogen + 40 kg/ha Phosphorus	41246.82	104400.00	63153.18	1.53
3.	T ₃ - 70 kg/ha Nitrogen + 60 kg/ha Phosphorus	42371.82	100800.00	58428.18	1.38
4.	T ₄ - 80 kg/ha Nitrogen + 20 kg/ha Phosphorus	40330.32	87200.00	46869.68	1.16
5.	T ₅ - 80 kg/ha Nitrogen + 40 kg/ha Phosphorus	41396.82	112460.00	71063.18	1.72
6.	T ₆ - 80 kg/ha Nitrogen + 60 kg/ha Phosphorus	42449.82	91800.00	49350.18	1.16
7.	T ₇ - 90 kg/ha Nitrogen + 20 kg/ha Phosphorus	40462.32	105800.00	65337.68	1.61
8.	T ₈ - 90 kg/ha Nitrogen + 40 kg/ha Phosphorus	41528.82	98400.00	56871.18	1.37
9.	T ₉ - 90 kg/ha Nitrogen + 60 kg/ha Phosphorus	42581.82	108020.00	65438.18	1.54

nitrogen + 60 kg/ha phosphorus) were found to be statistically at par with treatment 5 (80 kg/ha Nitrogen + 40 kg/ha Phosphorus).

Harvest index (%)

The significantly higher harvest index (33.90 %) was observed in treatment T₇ (90 kg/ha Nitrogen + 20 kg/ha Phosphorus) however the treatment 1 (70 kg/ha nitrogen + 20 kg/ha phosphorus), treatment 2 (70 kg/ha nitrogen + 40 kg/ha phosphorus), treatment 3 (70 kg/ha nitrogen + 60 kg/ha phosphorus), treatment 5 (80 kg/ha nitrogen + 40 kg/ha phosphorus) were found to be statistically at par with treatment 7 (90 kg/ha Nitrogen + 20 kg/ha Phosphorus). The application of phosphorus positively influenced yield-attributing traits by promoting vigorous crop growth, enhancing flowering and improving pod development, since P plays a key role in stimulating reproductive processes and seed formation. The overall enhancement of growth and yield parameters under phosphorus fertilization likely resulted in higher seed yield. These findings are in accordance with those reported earlier by Lanjewar and Selukar (2005), Gangwal *et al.* (2011), Solanki *et al.* (2016), Kumar *et al.* (2017), Gill *et al.* (2021), Dixit *et al.* (2023).

Economics

The economics of mustard as influenced by nitrogen and phosphorus levels (Table 7) revealed that the highest cost of cultivation (₹ 42,581.82/ha) was recorded under treatment T₉ (90 kg/ha Nitrogen + 60 kg/ha Phosphorus). However, treatment T₅ (80 kg/ha Nitrogen + 40 kg/ha Phosphorus) recorded the maximum gross return (₹ 112,460.00/ha), net return (₹ 71,063.18/ha), and benefit–cost ratio (1.72), indicating its superiority in terms of productivity as well as economic feasibility.

Conclusion

Based on the experimental findings, application of 80 kg/ha Nitrogen + 40 kg/ha Phosphorus (T₅) significantly enhanced growth and yield attributes of mustard, recording maximum plant height (136.51 cm), number of branches/plant (15.93), plant dry weight (24.24 g), number of siliquae/plant (220.07), seeds/siliqua (17.33), test weight (5.74 g), seed yield (1874.33 kg/ha), and stover yield (3843.67 kg/ha). This treatment also resulted in the highest economic returns with maximum gross return (₹ 112,460/ha), net return (₹ 71,063.18/ha), and benefit–cost ratio (1.72). Hence, application of 80 kg/ha Nitrogen + 40 kg/ha Phosphorus is recommended for achieving higher productivity and profitability in mustard cultivation.

References

- Ahmad, A., Abraham G., Gandotra N., Abrol Y.P. and Abdin M.Z. (1998). Interactive effect of nitrogen and sulphur on growth and yield of rape-seed-mustard (*Brassica juncea* L. Czern. and Coss. and *Brassica campestris* L.) genotypes. *J. Agron. Crop Sci.*, **181**(4), 193-199.
- Bankoti, P., Kumar K. and Kumar A. (2021). Effect of nitrogen rates on performance of mustard. *Brassica juncea. J. Pharmacog. Phytochem.*, **10**(1), 2847- 2850.
- Chauhan, Z.Y., Patel D.K. and Bhabhor K. (2020). Effect of nitrogen, phosphorus and sulphur on yield, nutrient uptake and soil fertility after harvest of mustard (*Brassica juncea* L.). *Int. J. Curr. Microbiol. Appl. Sci.*, **9**(6), 3506-3512.
- Chaurasiya, A., Singh S., Singh V., Singh N. and Singh A. (2019). Effect of nitrogen and sulphur nutrition on interaction effect, quality parameters, nutrient content or uptake & economics of Indian mustard (*Brassica juncea* L.) in Western UP. *Int. J. Chem. Stud.*, **7**(1), 787-791.
- Dixit, A., Singh P.K., Verma A. and Pandey D. (2023). Effect of levels of nitrogen and sulphur on growth, yield and

- quality of Indian mustard (*Brassica juncea* L.). *The Pharma Innov. J.*, **12(3)**, 5752-5756.
- Dongarkar, K.P., Pawar W.S., Khawale V.S., Khutate N.G. and Gudadhe N.N. (2005). Effect of nitrogen and sulphur on growth and yield of mustard (*Brassica juncea* L.). *J. Soils and Crops*, **15(1)**, 163-167.
- Gangwal, T.V., Patel M.V. and Jadav N.J. (2011). Effect of phosphorus, sulphur and phosphate solubilising bacteria on yield, nutrient uptake and soil fertility after harvest of mustard. *Indian J. Fertiliser*, **7**, 32-40.
- Gautam, S., Mishra S.K., Pandey H.P., Pathak R.K. and Pandey S. (2019). Effect of nitrogen, phosphorus, potassium, sulphur and zinc on yield and their attributing characteristics of mustard crop. *Int. J. Adv. Agricult. Sci. Technol.*, **6(10)**, 1-17.
- Gill, K.H., Brar S.A. and Singh G. (2021). Impact of phosphorus and sulphur on yield and quality of mustard: A review. *The Pharma Innov. J.*, **10(4)**, 954-957.
- Giri, P.R., Khawale V.S., Pawar W.S. and Sonawale A.B. (2005). Effect of phosphorus and sulphur application on growth and yield of *Brassica juncea* L. *J. Soils and Crops*, **15(2)**, 448-451.
- Keerthi, P., Pannu R.J., Dhaka A.K. and Chaudhary K. (2017). Effect of sowing time and nitrogen on growth, yield and nutrient uptake by Indian mustard (*Brassica juncea* L.) under Western Haryana. *Chem. Sci. Rev. Lett.*, **6(24)**, 2526-2532.
- Keivanrad, S. and Zandi P. (2013). Effect of nitrogen levels on growth, yield and oil quality of Indian mustard grown under different plant densities. *Cercetări Agronomice în Moldova* Vol. **XLVII**, No. 1 (157) / 2014,
- Khan, H., Khan M.A., Hussain I., Malik A.A. and Baloch M.S. (2000). Effect of nitrogen and phosphorus on growth and yield of *Brassica juncea* L. *Pak. J. Biolog. Sci.*, **3(8)**, 1231-1233.
- Khanpara, V.D., Porwalz B., Sahu M.P. and Patel J.C. (1993). Effect of nitrogen and sulphur on growth and yield of mustard (*Brassica juncea*). *Indian J. Agron.*, **38(2)**, 382.
- Khatkar, Y., Dawson J., Zade K.K., Dixit P.M. and Khatkar R. (2009). Effect of nitrogen, phosphorus and sulphur fertilization on growth and yield of mustard (*Brassica juncea* Coss). *Int. J. Agricult. Sci.*, **5(2)**, 396-398.
- Khatun, M. (2021). Effect of Nitrogen and Phosphorus on the Growth and Yield of Mustard (*Brassica napus*).
- Kumar, M., Singh P.K., Yadav K.G., Chaurasiya A. and Yadav A. (2017). Effect of nitrogen and sulphur nutrition on growth and yield of Indian mustard (*Brassica juncea* L.) in western UP. *J. Pharmacog. Phytochem.*, **SP1**, 445-448.
- Kumar, S., Verma S.K., Singh T.K. and Singh S. (2009). Effect of nitrogen and sulphur on growth, yield and nutrient uptake by Indian mustard (*Brassica juncea*) under rainfed condition. *Indian J. Agricult. Sci.*, **79(8)**, 648.
- Lanjewar, A.D. and Selukar S.S. (2005). Effect of phosphorus and sulphur application on nutrient uptake of mustard (*Brassica juncea* L.). *J. Soils and Crops*, **15**, 433-436.
- Mishra, S.V., Maurya D. and Gupta G. (2010). Effect of phosphorus and sulphur and their interaction on mustard crop. *Asian Sciences*, **5(2)**, 79-84.
- Mozaffari, S.N., Delkhosh B. and Rad A.S. (2012). Effect of nitrogen and potassium levels on yield and some of the agronomical characteristics in Mustard (*Brassica juncea*). *Indian J. Sci. Tech.*, **5(2)**, 2051-2054.
- Nath, S., Patel B.T., Meena O. and Jat G.P. (2018). Effect of phosphorus and sulphur on yield attributes, yield and economics of mustard [*Brassica juncea* (L.) Czern & Coss] in loamy sand. *J. Pharmacog. Phytochem.*, **7(5)**, 498-500.
- Patel, N.I. (2000). Effect of FYM, phosphorus, sulphur and their interaction on mustard- pearl millet cropping sequence in Typic Ustipsamments. *Ph.D. Thesis*, Gujarat Agricultural University, Sardarkrushinagar.
- Patel, V.K., Mishra U.S. and Singh V.K. (2022). Effect of the phosphorus and sulphur levels on growth and yield of mustard (*Brassica juncea* L.) crop under rainfed condition. *Int. J. Plant. Soil. Sci.*, **34**, 249-255.
- Pattam, K., Pannu R.K., Dhaka A.K. and Sharma K.D. (2017). Effect of dates of sowing and nitrogen levels on growth and yield of Indian mustard. *Int J Curr Microbiol Appl Sci.*, **6**, 1029-1036.
- Potdar, D.S. Purohit H.S. Meena R.H., Kaushik M.K., Jain H.K. and Ameta K.D. (2019). Effect of integrated phosphorus management on growth, yield and quality of mustard (*Brassica juncea* L.). *J. Pharmacog. Phytochem.*, **8(4)**, 1700-1704.
- Raghuvanshi, N., Kumar V. and Dev J. (2018). Effect of nitrogen levels on mustard (*Brassica juncea* (L.) Czern and Coss.) varieties under late sown condition. *Curr. J. Appl. Sci. Technol.*, **30(2)**, 1-8.
- Rajput, R.K., Singh S., Varma J., Rajput P., Singh M. and Nath S. (2018). Effect of different levels of nitrogen and sulphur on growth and yield of Indian mustard (*Brassica juncea* (L.) Czern and Coss.) in salt affected soil. *J. Pharmacog. Phytochem.*, **7(1)**, 1053-1055.
- Sahoo, R., Singh V. and Tiwari D. (2021). Effect of phosphorus and sulphur levels on growth and yield of yellow mustard (*Brassica campestris* L.). *The Pharma Innov. J.*, **10(9)**, 1988-1991.
- Sharma, A., Meena B.S., Meena R.K., Yadav R.K., Patidar B.K. and Kumar R. (2020). Effect of different levels of nitrogen, phosphorus and potassium on growth, yield attribution and yield of Indian mustard (*Brassica juncea* (L.) Czern and coss) in S-E Rajasthan. *Int. J. Curr. Microbiol. App. Sci.*, **9(9)**, 2216-2221.
- Sharma, R.P., Singh P. and Maliwal P.I. (2002). Effect of weed management and phosphorus levels on yield and quality of Indian mustard (*Brassica juncea*). *Indian J. Agricult. Sci.*, **72(8)**, 461-463.
- Shorna, S.I., Polash M.A.S., Sakil M.A., Mou M.A., Hakim M.A., Biswas A. and Hossain M.A. (2020). Effects of

- nitrogenous fertilizer on growth and yield of Mustard Green. *Tropical Plant Research*, **7(1)**, 30-36.
- Singh, P., Mandal B.M.K., Arsad and Gupta A. (2022). Effect of nitrogen on growth, yield and quality of Indian mustard (*Brassica juncea* L.) genotypes. *The Pharma Innov. J.*, **11(7)**, 3582-3587.
- Singh, S.B. and Thenua O.V.S. (2016). Effect of phosphorus and sulphur fertilization on yield and NPS uptake by mustard (*Brassica juncea* L.). *Progressive Res.-An Int. J.*, **11(1)**, 80-83.
- Solanki, L.R., Sharma M. and Indoria D. (2018). Effect of Phosphorus, Sulphur and PSB on Yield of Indian Mustard (*Brassica juncea* L.) and available Macronutrients in Soil. *J. Indian Soc. Soil Sci.*, **66(4)**, 415-419.
- Solanki, R.L. and Sharma M. (2016). Effect of phosphorus, sulphur and PSB on growth and yield of mustard in Southern Rajasthan. *Annals of Plant and Soil Research*, **18(1)**, 66-69.
- Solanki, R.L., Sharma M., Sharma S.K., Sharma F.L. and Jain H.K. (2016). Effect of phosphorus, sulphur and phosphate solubilizing bacteria on yield and micronutrient cation uptake of mustard [*Brassica juncea* (L.)] on a Haplustept. *Indian J. Fertilisers*, **12**, 36-41.
- Taki, L. (2022). Effect of phosphorus and magnesium on growth and yield characteristics of Indian mustard (*Brassica juncea* L.) in Kanpur. *The Pharma Innov. J.*, **11(6)**, 291-293.
- Tyagi, D.B., Nehal N. and Singh K.S. (2022) Effect of nitrogen and phosphorus application on yield and economics of Indian mustard (*Brassica juncea* L.). *Annals of Plant and Soil Research*, **24(4)**, 661-664.