Ecological Assessment of Available Nitrogen on the Soil of Vaishali Region and their impact on Productivity of Brassica Nigra and Sinapis Alba

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Abstract
a. Purpose: To enhance crop performance while mitigating environmental risks, providing a pathway to improved regional productivity and ecological sustainability on the productivity of oil seeds at the Vaishali region for Brassica nigra (black mustard) and Sinapis alba (white mustard), two vital oilseed crops
b. Methods: Collection of soil from various agricultural fields in the Vaishali region from a depth of 0–15 cm, and the N content was analyzed using the Kjeldahl method.
c. Results: Experimental plots revealed that higher N levels significantly enhanced the vegetative growth and seed yield of B. nigra, while moderate N levels optimized yield in S. alba. Low N availability restricted growth and productivity, particularly in S. alba.
d. Conclusions: This research finding is to adopt integrated nutrient management practices, periodic soil testing, the use of organic fertilizers, and crop rotation. Additionally, awareness programs for farmers are vital to promoting sustainable agricultural practices and maintaining soil health

Keywords: Available nitrogen for soil, Centimeters, Brassica nigra, Sinapis alba

1. Introduction

Nitrogen is an essential macronutrient critical for plant growth and crop productivity (Zayed et al., 2023). N availability in soil significantly impacts crop productivity. This study focuses on evaluating the N levels in the soil of the Vaishali region and their influence on the yield and growth of *Brassica nigra* (black mustard) and *Sinapis alba* (white mustard).The findings to provide insights into sustainable agricultural practices and improved productivity in the region. The soil in Vaishali showed varying levels of N influenced by cropping patterns, organic matter content, and fertilizer usage. Moderate N availability was found to optimize the productivity of *B. nigra* and *S. alba*. This research needs a balanced approach to soil nutrient management, ensuring both agricultural productivity and ecological sustainability.

Nitrogen, an indispensable macronutrient, plays a pivotal role in orchestrating the growth and development of plants, serving as a fundamental building block for essential biomolecules such as amino acids, proteins, nucleic acids, and chlorophyll(Md Nahid Hashan et al., 2023). . These nitrogenous compounds are integral to various physiological processes, including photosynthesis, respiration, and genetic information transfer, underscoring the critical importance of nitrogen for plant survival and productivity(Mabrouk et al., 2018) . While the Earth's atmosphere is abundant in nitrogen gas (N2), plants cannot directly utilize this form; instead, they rely on nitrogen fixation, a process by which N2 is converted into bioavailable forms like ammonia, primarily through the agency of microorganisms (Jaiswal et al., 2021). The availability of nitrogen in the soil directly influences plant vigor, canopy development, and ultimately, crop yield, particularly in the brassicaceae family, where nitrogen is often supplemented to enhance productivity (Md Nahid Hashan et al., 2023). Due to its central role in plant metabolism, nitrogen is often a limiting nutrient in agricultural systems, necessitating the application of nitrogen fertilizers to meet the demands of high-yielding crops (de Andrade et al., 2023)

Effects of Nitrogen Fertilizer on Sinapsis alba:

Nitrogen, an indispensable macronutrient, assumes a pivotal role in orchestrating the intricate physiological and biochemical processes that govern plant growth and development, exerting a profound influence on crop productivity. Nitrogen is a fundamental building block of essential biomolecules, including amino acids, proteins, nucleic acids, and chlorophyll, all of which are indispensable for plant survival and optimal performance (Ordóñez-Díaz et al., 2021). Consequently, nitrogen fertilization stands as a cornerstone of modern agricultural practices, with the overarching goal of augmenting crop yields and ensuring food security for a burgeoning global population (Kumar et al., 2021). The impact of nitrogen extends beyond mere yield enhancement, acting as a stimulating agent that finely tunes endogenous hormone levels, thereby fostering a harmonious equilibrium among various hormones, ultimately bolstering the plant's resilience against a myriad of environmental stressors (Men et al., 2020). It has been demonstrated that nitrogen fertilization can significantly increase plant height and branch production (Bhedela et al., 2024). An adequate supply of nitrogen is essential for the development of a robust canopy and the maintenance of a vibrant green color in crops, optimizing the leaf area index and overall leaf area (Bhedela et al., 2024). The judicious application of nitrogen fertilizer can significantly enhance the photosynthetic efficiency of plants (Xu Danghui;Gao Xiaogang;Jing MOU et all, 2018). Nitrogen directly influences the synthesis of chlorophyll, the pigment responsible for capturing light energy during photosynthesis, thereby facilitating the efficient conversion of carbon dioxide and water into carbohydrates, the plant's primary energy source. The application of nitrogen fertilizers, such as urea, has become a widespread practice in modern agriculture to overcome nitrogen limitations and boost crop yields (Zhao et al., 2022). The increasing global demand for food, coupled with soil degradation, has intensified the reliance on fertilizers to replenish soil nutrients and enhance agricultural productivity (Soze, I.M.S, et al.2018)

2. Objectives

- To determine the nitrogen content in soils of the Vaishali region.

- To analyze the relationship between soil nitrogen availability and the productivity of *Brassica nigra* and *Sinapis alba*.
- To recommend agricultural practices for optimizing nitrogen use and improving crop yields.

3. Materials and Methods:

Study Area: Vaishali region, characterized by its alluvial soil and semi-arid climate.
Soil Sampling**:** Selected twenty places in one heater of the agriculture field and collected one kilogram of soil samples from depths of 0–15 cm(Adriano, n.d.). All sample wear mixed and finally taken 500g of sample from properly mixed soil for testing of nitrogen(Antrekowitsch et al., 2023).
Nitrogen Analysis: The available nitrogen in the soil of Vaishali region was measured using the Kjeldahl method(Reader, n.d.) The field experiment for collection of soil sample was conducted at Vaishali district of Bihar from Patna University, research scholar for estimation of N to correlate the effect of N on productivity of *Brassica nigra* and *Sinapis alba* from five block as Bidupur, Hajipur, Sahdei Buzurg, Mahnar, and Desari having longitude 25.6452º N, 25.6924º N, 25.6626º N, 25.6100 º N, 25.6647º N and latitude 85.3336º E, 85.2083º E, 85.4611º E, 85.4941º E, 85.4040 º E, respectively. Above soil sample of Vaishali district was compared to Patna district block name Naubatpur having longitude 25.5026º N and latitude 84.9635º E to solve the problem of one of the major cooking oil plant productivity. Available N awas determined by using spectrophotometer method as described.The easily available nitrogen for plant was estimated by solution of potassium permanganate in highly alkaline medium using distilled water as solvent. The organic nitrogen present in the soil is oxidized by nascent oxygen liberated by potassium permanganate in the presence of highly alkaline medium of sodium hydroxide solution and the released ammonia is condensed and absorbed in a known volume of a standard boric acid solution containing mixed indicator(Rajamurugan et al., 2012). This is titrated with sulfuric acid solution till test sample colure matches to blank sample. 8g soil was put in to kjeldahl distillation flask made up of borosilicate glass then in same flask 10 ml distilled water, 40ml of 0.32% potassium permanganate and 40ml of 2.5% sodium hydroxide solution was added and the material digested. Then distillation tube was fitted into Kjeldahal instrument in operating condition for nine minute and distillated sample was collected into 2% of 20ml boric acid solution containing few drop of mixed indicator(Braga et al., 2020). After nine minute collected distillate was directly titrated with 0.01N sulfuric acid to get end point change from blue green colour to radish pink colour and volume of 0.01N sulfuric acid solution is used to get end point was noted(Sahay et al., 2015).Tabulated data show the relationship of available nitrogen for plant in soil of different block of Vaishali district and soil of Naubatpur block of Patna district kg/hector (Subbiah, n.d.)
Crop Cultivation: Experimental plots were established to grow *B. nigra* and *S. alba* under controlled nitrogen application levels. Using three different concentration of nitrogen 120kg/ha, 60kg/ha, 30kg/ha and blank having no use of nitrogen fertilizer (urea) wear applied for the production of seed for *B.nigra* and *S.alba* under natural environment of plant(Mitrović et al., 2020).
Parameters Studied: weight of seed produced after application of different concentration of nitrogen fertilizer wear noted of *B.nigra* and *S.alba.*

4. Statistical Analysis:

Analysis of the available Nitrogen on the soil of Vaishali region and their impact on productivity of *Brassica nigra* and *Sinapis alba* of the study subjects and controls was done using Two way ANOVA test

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at Alpha value of 0.05. Data entry and data analysis were done using Graph Pad Prism software. The p value was calculated, $p < 0.0001$ was considered to be significant.

5. Results and Discussion:

Soil Nitrogen Levels: The soil in Vaishali showed varying levels of nitrogen, influenced by cropping patterns, organic matter content, and fertilizer usage from Table -1

Table-1

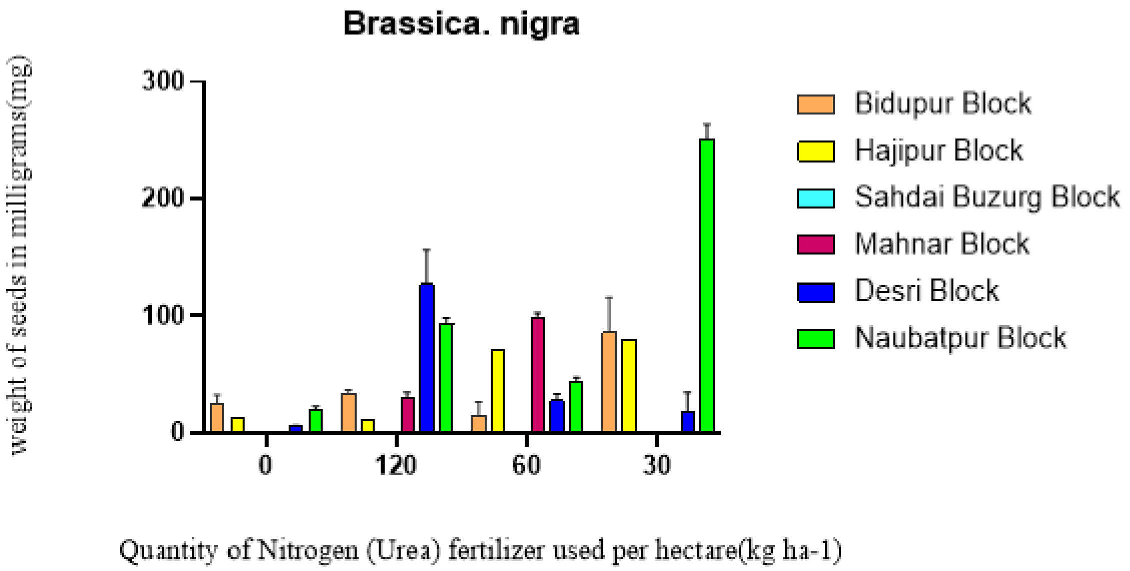
Name of different block for estimation of nitrogen from soil (Kg ha^{-1})						
S.No.	Bidupur Block	Hajipur Block	Sahdai Buzurg Block	Mahnar Block	Desri Block	Naubatpur Block
1	47	129.4	90.2	121.5	66.6	129.4

Crop Response: *Brassica nigra* depend upon nitrogen levels in soil led to increased vegetative growth and seed yield from table-2 and graphical representation from figure-1

Table-2

Weight of *Brassica nigra* seeds in milligrams (mg)							
S.No	Quantity of Nitrogen (Urea) fertilizer used per hectare(kg ha^{-1})	Bidupur Block	Hajipur Block	Sahdai Buzurg Block	Mahnar Block	Desri Block	Naubatpur Block
1	0	18	7	0	0	6	23
2	120	32	13	0	27	156	99
3	60	18	66	0	97	29	43
4	30	113	82	0	0	20	237

Figure-1: The graph is prepared by using graph pad prism soft ware and graph displays the weight of seeds in milligram (mg) of *Brassica nigra* in response to varying quantities of nitrogen (urea) fertilizer application per hectare (kg ha^{-1}). The data is grouped by different blocks of different district, each represented by a distinct color in the legend.



Observations:

Nitrogen Levels: The x-axis represents decreasing levels of nitrogen fertilizer applied (120, 60, 30 kg ha^{-1}, and 0 kg ha^{-1}).The y-axis shows the seed weight in milligrams of *Brassica nigra*

Block-wise Variation: Naubatpur Block (green) shows the highest seed weight of *Brassica nigra* particularly at the 30 kg ha^{-1} nitrogen level. The response of other blocks, like Desri (blue) and Sahdai Buzurg (bright green), varies, with moderate increases in seed weight of *Brassica nigra* at intermediate nitrogen levels.

Effect of Reduced Fertilizer: At 30 kg ha^{-1} nitrogen application, seed weight of *Brassica nigra* increases significantly for some blocks (e.g., Naubatpur) compared to higher nitrogen levels (e.g., 120 kg ha^{-1}).This indicates a potential optimal nitrogen level for certain regions.

Zero Nitrogen Treatment: All blocks show minimal seed weights of *Brassica nigra* when no nitrogen fertilizer is applied.

Table-3

Weight of ***Sinapis alba*** seeds in milligrams(mg)							
S.No	Quantity of Nitrogen (Urea) fertilizer used per hectare(kg ha^{-1})	Bidupur Block	Hajipur Block	Sahdai Buzurg Block	Mahnar Block	Desri Block	Naubatpur Block
1	0	19	32.5	0	4	17	6
2	120	52.5	98	4	20	123	122
3	60	63	11	48	76.5	61	64
4	30	64	2	87	50	86	97

The graph suggests a differential response of *Brassica nigra* seed weight to nitrogen levels across various blocks, likely due to soil fertility, environmental conditions management practices. Some blocks

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may achieve optimal seed weight at lower nitrogen levels, emphasizing the importance of site-specific fertilizer recommendations from Table-2

Crop Response: *Sinapis alba* depend upon nitrogen levels in soil led to increased vegetative growth and seed yield from table-3 and graphical representation from figure-2

Figure-2: The graph is prepared by using graph pad prism soft ware and graph displays the weight of seeds in milligram (mg) of *Sinapis alba* in response to varying quantities of nitrogen (urea) fertilizer application per hectare (kg ha^{-1}). The data is grouped by different blocks of different district, each represented by a distinct color in the legend.

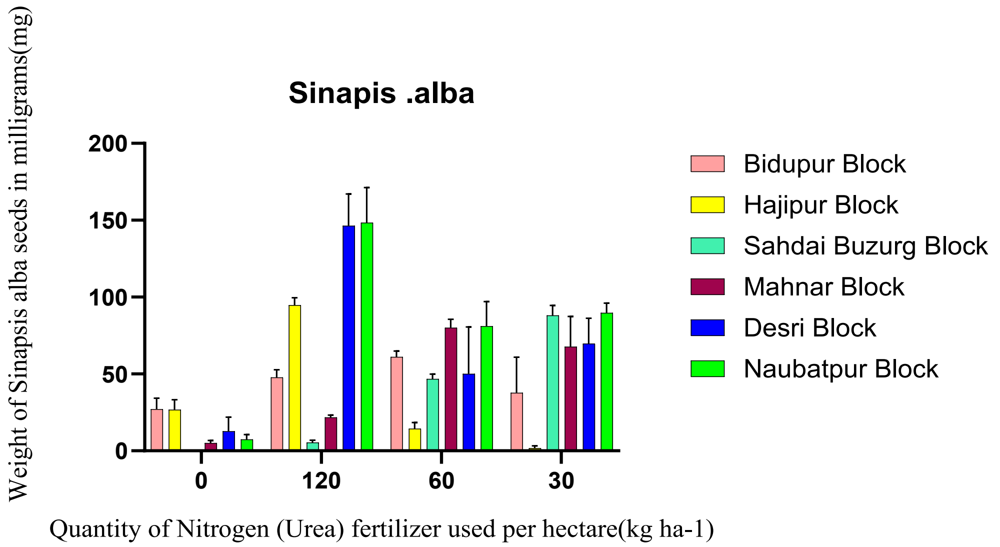

Figure-2

Observations:

Nitrogen Levels: The x-axis indicates decreasing levels of nitrogen fertilizer (120, 60, 30 and 0 kg ha^{-1}). The y-axis displays the seed weight in milligrams for *Sinapis alba*.

Block-Wise Variation: Hajipur Block (yellow) shows the highest seed weight at 120 kg ha^{-1} nitrogen followed by Sahdai Buzurg Block (bright green). At reduced nitrogen levels (60 and 30 kg ha^{-1}) seed weights tend to stabilize with smaller variations between blocks. Desri Block (blue) and Naubatpur Block (green) show consistent improvements across the lower nitrogen levels of (30–60 kg ha^{-1}) for *Sinapis alba*.

Effect of Reduced Fertilizer: Some blocks, such as Bidupur (pink) and Desri (blue), show marginally reduced seed weight at 120 kg ha^{-1} compared to lower nitrogen levels for *Sinapis alba.* .

Zero Nitrogen Treatment: Seed weight of *Sinapis alba* is lowest across all blocks when no nitrogen is applied, as expected

Interpretation:

Higher nitrogen application rates (120 kg ha^{-1}) generally lead to greater seed weight for *Sinapis alba*, particularly in Hajipur and Sahdai Buzurg Blocks, suggesting higher responsiveness of these regions to nitrogen fertilization. Decreasing trend in seed weight with excessive nitrogen in some blocks for *Sinapis alba* hints at a possible negative effect of over quantity fertilization use from Table-3

7. Comparative Conclusion for *Brassica nigra* and *Sinapis alba* Graphs:

Seed Weight Trends: *Brassica nigra* exhibits a sharp increase in seed weight at the lowest nitrogen level (30 kg ha^{-1}), especially in the Naubatpur Block (green), indicating a highly responsive or optimal range at lower nitrogen rates. *Sinapis alba* demonstrates a peak seed weight at the highest nitrogen level (120 kg ha^{-1}), particularly in Hajipur Block (yellow), suggesting it thrives under higher nitrogen application.

Block-Specific Performance: Naubatpur Block consistently performs well in both crops but with a stronger response at reduced nitrogen levels for *Brassica nigra*. Hajipur Block dominates in *Sinapis alba* at higher nitrogen levels, while other blocks show more balanced responses.

Nitrogen Efficiency: *Brassica nigra* appears more efficient, achieving high seed weights with lower nitrogen inputs. *Sinapis alba* requires higher nitrogen to maximize seed production, which could be less nitrogen-efficient.

Economic Implications: *Brassica nigra*, reduced nitrogen rates can be economical and environmentally sustainable due to its strong response at lower inputs. Whereas *Sinapis alba*, nitrogen application at higher levels is necessary but might increase production costs.

8. Recommendations:

Tailor nitrogen application rates to crop species and regional conditions for optimal seed yield. Conduct further studies to evaluate the long-term economic and environmental implications of the observed trends. Consider integrating other agronomic practices, such as organic matter addition, to complement nitrogen use for both crops.

9. Conclusion

The study highlights the significance of balanced nitrogen management for sustainable crop production in the Vaishali region. Moderate nitrogen availability was found to optimize the productivity of *B. nigra* and *S. alba*. Recommendations include adopting integrated nutrient management practices and periodic soil testing to enhance crop performance while minimizing environmental risks. This research underscores the need for a balanced approach to soil nutrient management, ensuring both agricultural productivity and ecological sustainability.

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