



Effect of Nitrogen and Boron on Growth Parameters, Yield Attributes and Yield of Mustard Crop in Chitrakoot Area

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during the *Rabi* season of 2022 at the Rajoula Agriculture farm, of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.). The present experiment having 13 treatment combinations replicated thrice in a randomized block design. Mustard variety Pusa Mahak was grown with recommended agronomic practices. Based on the results emanated from present investigation, it could be concluded that application of T₁₂ [$\frac{1}{2}$ of RDN + (1st nano-urea spray + 2nd nano-urea spray + 1.25 kg B)] significantly recorded maximum growth parameters such as plant height (198.8 cm), number of branches plant⁻¹ (8.7) and maximum yield attributing characters such as number of siliqua plant⁻¹ (166.8), number of seed siliqua⁻¹ (13.4) and 1000 seed weight (5.1 g). The result showed the highest grain yield (1523.81 kg ha⁻¹) and straw

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yield (4761.90 kg ha⁻¹), with treatment T₁₂ [½ of RDN + (1st nano-urea spray + 2nd nano-urea spray + 1.25 kg B)] in comparison to all the treatments. While the minimum value of growth parameters viz. plant height (171.2 cm), number of branches plant⁻¹ (6.3) and yield attributes such as number of siliqua plant⁻¹ (117.5), number of seed siliqua⁻¹ (11.7) and 1000 seed weight (3.8 g) recorded under the treatment T₁ [100 % NPK as per RDF].

Keywords: Nano-urea; mustard; yield; boron.

1. INTRODUCTION

“Indian mustard is one of the most important edible oilseed *rabi* crops of North India commonly known as *Sarson*, *Rai* or *Laha*. It belongs to the family Brassicaceae and the genus *Brassica*. It comprises various traditionally grown indigenous species, namely, Toria (*Brassica campestris* L. var. toria), Brown sarson (*Brassica campestris* L. var. brown sarson), Yellow sarson (*Brassica campestris* L. var. yellow sarson), Black mustard (*Brassica nigra*) and Taramira (*Eruca sativa/vesicaria* Mill.) which are grown over different parts of the country” [1].

“Rapeseed mustard is the second most consumed edible oilseed crop in India, after soybean. India has 6.23 million hectares area under rapeseed mustard and 9.34 million tonnes production with average productivity of 1499 kg ha⁻¹, which is about three-fourths of the world's average productivity (1960 kg ha⁻¹)” (DAC & FW, 2020). “Rajasthan ranks first both in terms of area and production of Indian mustard, which accounts for 45% of mustard in the country. It is the most important *rabi* season oilseed crop of Rajasthan which is grown on 2.18 million hectares with annual production of 3.40 million tonnes at an average productivity of 1558 kg ha⁻¹” [2]. “In the Madhya Pradesh, it is grown on an area 1038.15 thousand hectares with a production of 1.69 million tonnes” [3].

“Urea is a rich source of nitrogen, an essential nutrient for plant growth. Nitrogen is a crucial component of chlorophyll, the green pigment in plants responsible for photosynthesis. Adequate nitrogen supply helps mustard plants produce more chlorophyll, leading to improved photosynthesis and overall plant growth. Mustard plants respond well to nitrogen fertilizers like urea during their vegetative stage” [4]. Urea provides the necessary nitrogen for the formation of leaves, stems, and branches, resulting in increased plant height and canopy development. “This can lead to better light interception and more efficient utilization of sunlight. The application of urea at the right time and in the

right amount can significantly increase mustard crop yield. One of the most common symptoms of nitrogen deficiency is the yellowing of older leaves, starting from the tips and progressing toward the base of the plant. Urea deficiency can lead to reduced plant height, fewer branches, and a generally stunted appearance. Mustard plants may fail to reach their full growth potential” [5].

“Nano fertilizers possess unique features that enhance plant performance in terms of ultrahigh absorption, increase in production, and rise in the leaf's surface area. Besides the controlled release of nutrients contributes to preventing eutrophication and pollution in water resources. Replacement of traditional fertilizers by nano fertilizer is beneficial as upon application, it releases nutrients into the soil steadily and in a controlled way, thus, preventing water pollution” [6,7].

“Among most recent technical improvements in the field of agriculture nanotechnology holds an eminent position in remodeling agriculture and food production to fulfil the demands in an efficiently and cost-effectively way. Nanotechnology is a promising tool and has the potential to foster a new era of precise farming techniques and therefore, may emerge as a possible solution for their problems. Nanotechnology has the potential to improve global food production and food quality” [8]. “Nano fertilizers are nutrient carriers of nano dimensions ranging from 30-40 nm and capable of holding bountiful of nutrient ions due to their high surface area and released it slowly and steadily that commensurate with crop demand and have a profound influence on crop production” [9,10].

Boron is essential for the formation and stability of plant cell walls. It is involved in the cross-linking of pectin molecules, which helps maintain the structural integrity of plant cells. In mustard plants, this is especially important for maintaining stem and seed pod strength. Adequate boron levels promote efficient pollination and higher

seed set, ultimately contributing to increased yield. Boron aids in the uptake and translocation of other essential nutrients within the plant. It helps in the movement of calcium, which is important for cell division and overall plant growth [11]. Boron deficiency in mustard often leads to the development of distorted, misshapen, and brittle young leaves and stems. This is known as "dieback" or "little leaf" syndrome. Boron deficiency can result in reduced flower formation and poor fruit or seed development. Flowers may drop prematurely, leading to decreased yield. In severe cases of boron deficiency, mustard stems can become hollow or brittle. This can make the plant more susceptible to lodging (falling over) and disease [12].

Keeping in view the significance of potassic fertilizers in combination with organic manures on growth parameters, yield components and yield of pigeon pea present investigation was undertaken at Rajoula Agriculture farm, of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.)

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was carried out at Rajoula Agriculture farm, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.) which lies in the semi- arid and sub-tropical region of Madhya Pradesh between 25.148° North latitude and 80.855° East longitude. The altitude of town is about 190-210 meter above mean sea level.

2.2 Edaphic Condition

The soil was moist, well drained with uniform plane topography. The soil of the experimental field was alluvial in origin, sandy loam in texture and slightly alkaline in reaction having pH 7.4 (1:2.5 soil: water suspension method given by [13]), low in organic carbon percentage in soil is 0.31 per cent (Walkley and Black's rapid titration method given by [14]), low in available nitrogen 97.68 kg ha⁻¹ (Alkaline permanganate method given by [15]), medium in available phosphorus as sodium bicarbonate-extractable P was 16.25 kg ha⁻¹ (Olsen's calorimetrically method, [16]), high in available potassium was 292.90 kg ha⁻¹ (Flame photometer method given by [17]), low in available boron 0.38 mg kg⁻¹ (Azomethine-H method given by [18])

2.3 Experimental Details

The experiment was laid out in randomized block design and replicated thrice comprising with 12 treatment combinations.

2.4 Fertilizer Application

FYM was applied @ 10 q ha⁻¹ as basal dose. After the layout of experimental plot, the fertilizers were weighed and applied in the plots and thoroughly mixed with soil. As per the experimental recommended doses of Nitrogen, Phosphorus, Potassium was applied to assigned plots. Recommended dose of Nitrogen, Phosphorus and Potassium were applied through Urea, DAP and MOP (60:40:40 kg ha⁻¹) whereas boron was applied through borax (0, 0.5, 1.0, 1.25 kg B ha⁻¹).

2.4.1 Seed and sowing

The seed sowing was done on 19th Nov. 2022. The seed was sown in line after making a narrow furrow with the help of pointed wooden stick at different row spacing. The seeds were dropped in the furrow after mixture with fine dust of soil and then after seeds were covered with thin soil layer. The total quantity of seed was required @ 6 kg/ha. The Mustard variety was "Pusa Mahak".

2.4.2 Harvesting

The crop was harvested on 14th Feb., 2023 when it reached to its physiological maturity i.e. when the leaves were turned yellow and more than 70 % capsules were full matured to avoid shattering of the crop.

2.5 Observations Recorded

2.5.1 Grain yield (q ha⁻¹)

The total weight of clean and dried grains from each plot was weighed with the help of electronic balance in kg/ha.

2.5.2 Straw yield (q ha⁻¹)

Straw yield of each plot can be obtained by deducting the grain yield from the respective biological yield and expressed in kg/ha.

2.6 Statistical Analysis

The data on various characters studied during the course of investigation were statistically analyzed for randomized block design. Wherever

Table 1. Treatment details

| Symbol | Treatment Combinations | Details of Treatment |
|-----------------|-------------------------------|--|
| T ₀ | | 100 % NPK as per RDF |
| T ₁ | N ₀ B ₀ | ½ of RDN + (2 water spray + 0.0 kg B) |
| T ₂ | N ₁ B ₀ | ½ of RDN + (1 st nano-urea spray + 2 nd water spray + 0.0 kg B) |
| T ₃ | N ₂ B ₀ | ½ of RDN + (1 st nano-urea spray + 2 nd nano-urea spray + 0.0 kg B) |
| T ₄ | N ₀ B ₁ | ½ of RDN + (2 water spray + 0.5 kg B) |
| T ₅ | N ₁ B ₁ | ½ of RDN + (1 st nano-urea spray + 2 nd water spray + 0.5 kg B) |
| T ₆ | N ₂ B ₁ | ½ of RDN + (1 st nano-urea spray + 2 nd nano-urea spray + 0.5 kg B) |
| T ₇ | N ₀ B ₂ | ½ of RDN + (2 water spray + 1.0 kg B) |
| T ₈ | N ₁ B ₂ | ½ of RDN + (1 st nano-urea spray + 2 nd water spray + 1.0 kg B) |
| T ₉ | N ₂ B ₂ | ½ of RDN + (1 st nano-urea spray + 2 nd nano-urea spray + 1.0 kg B) |
| T ₁₀ | N ₀ B ₃ | ½ of RDN + (2 water spray + 1.25 kg B) |
| T ₁₁ | N ₁ B ₃ | ½ of RDN + (1 st nano-urea spray + 2 nd water spray + 1.25 kg B) |
| T ₁₂ | N ₂ B ₃ | ½ of RDN + (1 st nano-urea spray + 2 nd nano-urea spray + 1.25 kg B) |

Note: Recommended dose of fertilizer (60:40:40 kg ha⁻¹) was applied

treatment differences were significant ("F" test), critical differences were worked out at five per cent probability level. The data obtained during the study were analyzed statistically using the methods advocated by Gomez and Gomez [19].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Data pertaining to growth parameters mainly plant height (cm), and number of branches plant⁻¹ are presented in Table 2 clearly revealed that application of nano urea and boron increased these attributes significantly over control. The results revealed that the plant height varied in between 171.2 to 198.8 cm and all the treatments were significantly superior to treatment T₁ [100 % NPK as per RDF]. The treatment combination T₁₂ [½ of RDN + (1st nano-urea spray + 2nd nano-urea spray + 1.25 kg B)] gave the maximum plant height (198.8). Number of branches plant⁻¹ of mustard varied in between 6.3 to 8.7 and all the treatments were significantly superior to T₁ [100 % NPK as per RDF]. The treatment combination T₁₂ [½ of RDN + (1st nano-urea spray + 2nd nano-urea spray + 1.25 kg B)] gave the maximum no. of branches plant⁻¹ (8.7). Minimum plant height (171.2 cm) and number of branches plant⁻¹ (6.3) were associated with the treatment T₀ [100 % NPK as per RDF]. These findings are further supported

by Khan et al. [20], Shagata et al. [21] and Satyanarayana et al. [22].

The scientific significance of this study extends beyond its immediate agricultural implications. It addresses broader ecological concerns by delving into the relationships between nutrient supplementation, crop growth, and environmental sustainability [23-25]. The knowledge gained from this research can inform strategies for mitigating the environmental impacts of agricultural practices, such as reducing excess nutrient runoff that can harm aquatic ecosystems [26,27,28]. Additionally, by comparing the results with studies in tropical territories, this research has the potential to identify patterns and generalizable insights that can be applied to other regions facing similar climatic and soil challenges [28,29]. Overall, the study's scientific relevance lies in its potential to enhance agricultural productivity, reduce environmental impacts, and contribute to the global effort to address food security and sustainability challenges in tropical regions.

3.2 Yield Components

Data pertaining to yield attributing parameters mainly no. of siliqua plant⁻¹, no. of seed siliqua⁻¹ and 1000 seed weight (g) are presented in Table 3 clearly revealed that application of nano urea in combination with boron increased yield attributes

significantly over control except 1000 seed weight (g). Maximum no. of siliqua plant⁻¹ (166.8), no. of seed siliqua⁻¹ (13.4) and 1000 seed weight (5.1 g) were recorded under the treatment T₁₂ [½ of RDN + (1st nano-urea spray + 2nd nano-urea spray + 1.25 kg B)] followed by treatment T₉ [½ of RDN + (1st nano-urea spray + 2nd nano-urea spray + 1.0 kg B)] with the value 164.7, 13.2 and 5.0 g respectively and the minimum no. of siliqua plant⁻¹ (117.5) no. of seed siliqua⁻¹ (11.7) and 1000 seed weight (3.8 g) was recorded under the treatment T₀ [100 % NPK as per RDF]. These findings are further supported by Khatkar et

al. [30], Kumar et al. [31] and Choudhary et al. [32].

3.3 Productivity Parameters

It was observed that application of nano urea and boron both enhanced the grain yield and straw yield of mustard significantly and present in Table. 4. Maximum grain yield (1523.81 kg ha⁻¹) was recorded under the treatment T₁₂ [½ of RDN + (1st nano-urea spray + 2nd nano-urea spray + 1.25 kg B)] followed by treatment T₉ [½ of RDN + (1st nano-urea spray + 2nd nano-urea spray + 1.0 kg B)] with the value 1485.71 kg ha⁻¹ and the

Table 2. Effect of different treatment combinations on growth parameters of mustard

| Treatment | Plant height (cm) | No. of branches plant ⁻¹ |
|-----------------------|-------------------|-------------------------------------|
| T ₀ | 171.2 | 6.3 |
| T ₁ | 174.8 | 6.5 |
| T ₂ | 177.3 | 6.7 |
| T ₃ | 183.4 | 7.0 |
| T ₄ | 180.5 | 6.8 |
| T ₅ | 185.7 | 7.1 |
| T ₆ | 188.3 | 7.5 |
| T ₇ | 186.1 | 7.3 |
| T ₈ | 193.2 | 8.0 |
| T ₉ | 196.8 | 8.4 |
| T ₁₀ | 191.5 | 7.7 |
| T ₁₁ | 194.6 | 8.2 |
| T ₁₂ | 198.8 | 8.7 |
| S.E.m± | 1.31 | 0.25 |
| C.D. (P= 0.05) | 3.94 | 0.76 |

Table 3. Effect of different treatment combinations on yield attributes of mustard

| Treatment | No. of siliqua plant ⁻¹ | No. of Seed siliqua ⁻¹ | 1000 seed weight (g) |
|-----------------------|------------------------------------|-----------------------------------|----------------------|
| T ₀ | 117.5 | 11.7 | 3.8 |
| T ₁ | 126.4 | 11.9 | 3.8 |
| T ₂ | 132.2 | 12.1 | 3.9 |
| T ₃ | 140.9 | 12.4 | 4.1 |
| T ₄ | 136.7 | 12.2 | 4.0 |
| T ₅ | 144.4 | 12.5 | 4.2 |
| T ₆ | 152.3 | 12.8 | 4.5 |
| T ₇ | 149.5 | 12.6 | 4.3 |
| T ₈ | 159.7 | 13.0 | 4.7 |
| T ₉ | 164.7 | 13.2 | 5.0 |
| T ₁₀ | 156.4 | 12.9 | 4.6 |
| T ₁₁ | 161.2 | 13.1 | 4.9 |
| T ₁₂ | 166.8 | 13.4 | 5.1 |
| S.E.m± | 6.19 | 0.16 | 0.08 |
| C.D. (P= 0.05) | 18.58 | 0.49 | NS |

Table 4. Effect of different treatment combinations on yields of mustard

| Treatment | Grain yield (kg ha⁻¹) | Stover yield (kg ha⁻¹) |
|-----------------------|---|--|
| T ₀ | 958.73 | 3498.41 |
| T ₁ | 1009.52 | 3631.74 |
| T ₂ | 1066.67 | 3771.42 |
| T ₃ | 1155.55 | 4012.69 |
| T ₄ | 1117.46 | 3879.36 |
| T ₅ | 1212.70 | 4133.33 |
| T ₆ | 1346.03 | 4374.60 |
| T ₇ | 1295.24 | 4279.36 |
| T ₈ | 1422.22 | 4539.68 |
| T ₉ | 1485.71 | 4685.71 |
| T ₁₀ | 1384.13 | 4457.14 |
| T ₁₁ | 1453.97 | 4628.57 |
| T ₁₂ | 1523.81 | 4761.90 |
| S.E.m± | 3.64 | 7.84 |
| C.D. (P= 0.05) | 10.75 | 23.14 |

minimum grain yield (958.73 kg ha⁻¹) was recorded under the treatment T₀ [100 % NPK as per RDF]. Maximum stover yield (4761.90 kg ha⁻¹) was recorded under the treatment T₁₂ [½ of RDN + (1st nano-urea spray + 2nd nano-urea spray + 1.25 kg B)] followed by treatment T₉ [½ of RDN + (1st nano-urea spray + 2nd nano-urea spray + 1.0 kg B)] with the value 4685.71 kg ha⁻¹ and the minimum stover yield (3498.41 kg ha⁻¹) was recorded under the treatment T₀ [100 % NPK as per RDF]. These findings are further supported by the findings of Rashid et al. [33], Sharma et al. [11], Kumar et al. [34] and Dhaliwal et al. [35].

Understanding the impact of nitrogen and boron on mustard crop growth and yield is pivotal for enhancing agricultural productivity, especially in regions like Chitrakoot, which may face specific soil [36] and climate challenges [37]. This research can provide valuable insights into optimizing nutrient management practices to achieve higher yields while conserving resources (Araya-Alman *et al.* 2020). Furthermore, comparing the findings with existing studies on soil quality and productivity in tropical territories broadens the scope of this research, facilitating a more comprehensive understanding of how specific nutrient amendments can contribute to sustainable agricultural practices in tropical regions worldwide [38,39]. Such comparative analysis not only aids local farmers but also contributes to the global pursuit of sustainable agriculture amidst changing environmental conditions [40,24,25].

4. CONCLUSION

The experimental results indicated that superiority in regard to growth parameters, yield components and productivity parameters *viz*, grain yield (kg ha⁻¹), stover yield (kg ha⁻¹), with the use of treatment combination T₁₂ [½ of RDN + (1st nano-urea spray + 2nd nano-urea spray + 1.25 kg B)] gave in soil ensure highest growth parameters, yield components and productivity, of mustard crop as comparison to all the treatments.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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