**Economic Assessment of Canola (Gobhi Sarson) as Influenced by Sowing Dates and Bio-Fertilizer Levels in Dehradun Region**

**Abstract:**

**Aims:**
The study aimed to assess the impact of different sowing dates and bio-fertilizer combinations on the yield and economic performance of canola (Brassica napus) under Dehradun agro-climatic conditions.

**Study Design:**

Factorial Randomized Block Design (FRBD) with 18 treatment combinations replicated thrice.

**Place and Duration of Study:**

The field experiment was conducted during Rabi season 2021–2022 at the Research Farm of Shivalik Institute of Professional Studies, Dehradun, Uttarakhand, India.

**Methodology:**
Three sowing dates (S1: 23rd October, S2: 4th November, S3: 14th November) and six bio-fertilizer treatments (D1 to D6 including organic sulphur and inoculants like Azotobacter, PSB, and SSB) were tested. Yield parameters, cost of cultivation, gross income, net returns, and benefit-cost (B:C) ratio were evaluated.

**Results:**
The 4th November sowing (S2) recorded the highest grain yield (17.8 q/ha), net income (₹41,604/ha), and B:C ratio (1:2.19). Among bio-fertilizers, treatment D4 (Organic Sulphur + SSB) yielded the highest economic return (₹37,282/ha) and B:C ratio (1:1.98), followed closely by D5. The lowest economic performance was observed in the absolute control (D6).

**Conclusion:**
The combination of timely sowing (4th November) and sulphur solubilizing bio-fertilizers enhances both yield and profitability in canola cultivation. These findings advocate for integrated, eco-friendly agronomic practices in oilseed farming for sustainable productivity.

**Keywords:** Canola, sowing date, bio-fertilizer, economic analysis, net return, B:C ratio, Gross income and cost of cultivation

**Introduction:**

Oilseed occupies an important place in the agricultural and industrial economy of India. Oilseeds have an important place in Indian agriculture next to cereals. India is the fourth largest contributor of oilseeds. Among various oilseed crops grown in India. Rapeseed –mustard contributes 28.6 % in the total production of oilseeds. Globally, India account for 19.8 % and 9.8% of the total acreage and production (USDA, 2022; Bhagat *et al*., 2022). Rapeseed- mustard is third important oilseed crop in the world after soybean and palm oil (Kaur *et al.,* 2022). It is grown under a wide range of agro-climatic conditions. Indian mustard is the most important member of the group, accounting for more than 70% of the area under rapeseed-mustard. An average yield of rapeseed and mustard was8.0 million tones during 2019-20.The productivity of rapeseed-mustard in India is still below the world average (1976 kg ha-1).

Rapeseed-mustard, commonly known as canola or "gobhi sarson" in India, is a vital oilseed crop cultivated globally for its high-quality edible oil and protein-rich meal.In India, it holds significant importance, contributing approximately 22.2% to the total area and 22.6% to the production of the nine major oilseeds grown in the country. Uttarakhand, a northern state characterized by its diverse agro-climatic zones, has been engaged in rapeseed-mustard cultivation, particularly in regions like Dehradun.The state's varied topography offers both opportunities and challenges for agriculture. According to the Directorate of Economics and Statistics, Department of Agriculture and Farmers Welfare, the agricultural yield of rapeseed-mustard in Uttarakhand was reported at 907 kg/ha in 2022 marking an increase from 878 kg/ha in 2021 (Khatiwada *et al.,* 2021)..

Uttarakhand state's total cultivated area of approximately 0.8 million hectares, with around 42.9% under irrigation, it is imperative to focus on optimizing agronomic practices to enhance crop productivity and economic returns (Kumar *et al.,* 2024). The timing of sowing and the application of bio-fertilizers are critical factors influencing the yield and profitability of rapeseed-mustard cultivation. Appropriate sowing dates ensure that the crop benefits from favorable environmental conditions during its growth stages, while bio-fertilizers enhance soil fertility and promote plant growth through natural processes. In the context of Dehradun's specific agro-climatic conditions, understanding the combined effect of these factors is essential for developing sustainable and profitable cultivation practices. Agronomic practices, including sowing time and bio-fertilizer use, are known to impact both yield and profitability in oilseed crops (Meena *et al*., 2017; Samant & Panigrahi, 2018). Bio-fertilizers like Azotobacter, phosphorus solubilizing bacteria (PSB), and sulphur solubilizing bacteria (SSB) enhance nutrient availability, soil health, and sustainability (Jain *et al.*, 2024; Prajapati et al., 2024). Optimizing these factors is critical in regions like Dehradun, where topographical and climatic variability can affect agricultural productivity.

 The study entitled “Economic Assessment of Canola (Gobhi Sarson) as Influenced by Sowing Dates and Bio-Fertilizer Levels in Dehradun Region” contributes significantly to the scientific understanding of sustainable agronomic practices in oilseed cultivation. The findings emphasize how optimized sowing dates and the use of eco-friendly bio-fertilizers influence economic returns and productivity of canola. This research provides localized recommendations for farmers in the Himalayan foothills, ensuring better yield, soil health, and climate-resilient agriculture. It also supports global efforts towards sustainable agriculture and input efficiency. This study aims to evaluate the impact of different sowing dates and bio-fertilizer applications on the economic performance of rapeseed-mustard in the Dehradun region. The findings are expected to provide valuable insights for farmers and agronomists to optimize cultivation strategies, thereby improving yield and profitability in similar agro-ecological zones.

**Materials and Methods:**

The field experiments were conducted at Research Farm of Shivalik Institute of Professional Studies, Dehradun on Economic Assessment of Canola (Gobhi Sarson) as Influenced by Sowing Dates and Bio-Fertilizer Levels in Dehradun Region during 2021-22. The treatments was laid out in Factorial Randomized Block Design having with 18 treatments and 3 replication having two factors first factor included different dates of sowing i.e. 10 days before optimum date (S1) , Optimum date (S2), 10 days after o ptimum date (S3) and Second factors included sulphur application and inoculation of biofertilizers i.e. Organic Sulphur @ 40 kg/ha (D1), Organic Sulphur @ 40 kg/ha + Azotobacter(D2), Organic Sulphur @ 40 kg/ha +Phosphorus Solubilizing Bacteria (D3), Organic Sulphur @ 40 kg/ha + Sulphur Solubilizing Bacteria (D4), Organic Sulphur+ Azotobacter +Phosphorus Solubilizing Bacteria + Sulphur Solubilizing (D5) and Absolute control (D6).

**ECONOMIC ANALYSIS**

**Cost of Cultivation (Rs ha-1)**

The cost of cultivation of canola crops was calculated including treatment cost on the basis of local market price of different inputs used in cultivation.

 **Gross returns (Rs ha-1)**

The monetary value of grain yield and straw yield was computed in rupees using the market price of outputs. Gross return was obtained by adding the monetary values of both grains and straw.

Gross Return (Rs ha-1) = Grain yield (q ha-1) × price (Rs. q-1) +

Straw yield (q ha-1) × price (Rs. q-1)

**Net returns (Rs ha-1)**

The net return for each treatment combination was calculated by deducting the cost of cultivation from the respective grass return.

Net Return (Rs. ha-1) = Gross return – Cost of cultivation

**Benefit: Cost ratio**

The net benefit: cost ratio was computed for the crop as well as for the system by the following formula:

**Benefit: cost ratio =**𝐍𝐞𝐭𝐫𝐞𝐭𝐮𝐫𝐧 (𝐑𝐬./ 𝐡𝐚)𝐂𝐨𝐬𝐭𝐨𝐟𝐜𝐮𝐥𝐭𝐢𝐯𝐚𝐭𝐢𝐨𝐧 (𝐑𝐬./ 𝐡𝐚)

**Result and Discussion:**

The present investigation was carried out to assess the impact of varying sowing dates and bio-fertilizer treatments on the yield performance and economic viability of canola (Brassica napus). The results indicated that both the timing of sowing and the nature of bio-fertilizer application significantly influenced grain and straw yield, cost of cultivation, and economic parameters such as gross income, net income, and benefit-cost ratio. The findings are discussed in detail below.

### ****Effect of Sowing Dates on Yield and Economic Returns****

Sowing time plays a pivotal role in influencing crop growth, development, and eventual yield, primarily by determining the climatic conditions during various growth stages. In the current study, three sowing dates were assessed: 23rd October (S1), 4th November (S2), and 14th November (S3). The findings demonstrated that the second sowing date (S2) produced the most favorable results in terms of both yield and economic outcomes.

Specifically, the grain yield obtained from the 4th November sowing was 17.8 q/ha, the highest among the three sowing dates. This was closely followed by 23rd October sowing (17.09 q/ha), while the latest sowing on 14th November resulted in the lowest grain yield of 16.22 q/ha. Similar trends were recorded for straw yield, where S2 again outperformed other dates with 35.22 q/ha, followed by 32.67 q/ha under S1 and 30.94 q/ha under S3. Similar results were observed by Bhagat *et al*. (2022), who highlighted mid-season sowing as optimal for canola productivity.

Economically, sowing on 4th November (S2) generated the maximum gross income of Rs. 76,464/ha and a net income of Rs. 41,604/ha, along with the highest benefit-cost ratio of 1:2.19. While the 14th November sowing (S3) resulted in lower yield, it achieved a respectable net income of Rs. 35,940/ha, primarily due to reduce cultivation expenses, corroborating findings by Meena *et al.* (2021) and Keerthi *et al.* (2017), who reported that delayed sowing negatively affects oilseed yield due to suboptimal reproductive phase conditions. Sowing on 23rd October (S1) generated a net income of Rs. 37,487/ha and a B:C ratio of 1:2.05, positioning it as an intermediate choice.

The superior performance of the 4th November sowing date can likely be attributed to the alignment of crop growth stages with favorable environmental conditions, including optimum temperature and moisture availability during germination, vegetative growth, and reproductive development. In contrast, early sowing may have exposed the crop to unfavorable climatic variability at later stages, and late sowing might have subjected the crop to suboptimal conditions during flowering and grain filling, thereby reducing yield potential.

### ****Effect of Bio-Fertilizer Treatments on Yield and Economics****

Bio-fertilizers enhance nutrient uptake efficiency, enrich soil microbial activity, and contribute to better plant health. In this study, six treatment regimes were assessed to understand their influence on canola productivity. These included organic sulphur alone and in combination with various microbial inoculants such as Azotobacter, phosphorus solubilizing bacteria (PSB), and sulphur solubilizing bacteria (SSB).

Among the treatments, D4 (Organic Sulphur @ 40 kg/ha + SSB) emerged as the most effective, producing the highest grain yield of 17.5 q/ha and straw yield of 35.09 q/ha. This was followed by D5 (OS + Azotobacter + PSB + SSB), which recorded a grain yield of 17.08 q/ha and a straw yield of 34.67 q/ha. On the other hand, the control treatment (D6) without any bio-fertilizer application resulted in the lowest grain yield (14.9 q/ha) and straw yield (30.65 q/ha), clearly highlighting the positive impact of bio-fertilizer use, Emphasizing the effectiveness of integrated microbial nutrient management (Prajapati et al., 2024; Sharma et al., 2021). These findings align with those by Jain *et al.* (2024), who reported that bio-fertilizers enhance nutrient uptake and economic gains in pulses and oilseeds.

The economic analysis indicated the yield outcomes. D4 treatment recorded the highest gross income of Rs. 75,268/ha and net income of Rs. 37,282/ha, with a benefit-cost ratio of 1:1.98. The integrated treatment D5 closely followed, with a net return of Rs. 36,541/ha and the same B:C ratio. The control (D6), with a net return of Rs. 28,265/ha and a B:C ratio of 1:1.78, was the least profitable, similar finding conducted by Kumari *et al.* (2012) and Sharma *et al.* (2016) on nutrient enhancement through microbial inoculants.

The effectiveness of the D4 treatment can be attributed to the enhanced availability of sulphur due to the presence of SSB, which plays a vital role in oil and protein synthesis in canola. Likewise, the comprehensive microbial treatment in D5 may have exerted a synergistic effect by simultaneously improving the availability of nitrogen, phosphorus, and sulphur—essential macronutrients for oilseed crops as emphasized by Sharma *et al.* (2018) and Monfared *et al.* (2020).

Treatments D2 and D3, although not the top performers, still recorded improved yields and economic benefits over the control, signifying the incremental value of each microbial addition. Their B:C ratios ranged between 1:1.84 and 1:1.88, validating the economic viability of adopting these treatments.

### ****Comparative Analysis and Practical Implications****

The combined evaluation of sowing dates and bio-fertilizer treatments reveals important strategic insights for canola cultivation:

* The optimal strategy for maximizing both yield and profit involved sowing on 4th November combined with D4 (OS + SSB) or D5 (OS + Azotobacter + PSB + SSB).
* Delayed sowing (S3), even when supplemented with bio-fertilizers, failed to fully compensate for the losses in productivity caused by suboptimal environmental conditions.
* Bio-fertilizers offer a sustainable alternative to chemical inputs and improve overall soil health, paving the way for long-term agricultural resilience.
* Adoption of an integrated nutrient management system—combining organic inputs with beneficial microbes—not only improves yield but also offers better economic returns, especially when combined with well-timed sowing.

These results support previous research advocating the use of biological inputs in enhancing oilseed productivity and underline the role of timely sowing as a crucial agronomic factor. The study confirms that a thoughtful combination of planting date and nutrient management strategy can significantly improve the biological and economic performance of canola cropping system.

**Table: 1 Effect of sowing dates and bio-fertilizer doses on Yield and Economics of canola**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatment** | **Grain yield** **(q ha-1 )** | **Straw yield** **(q ha-1 )** | **Cost of cultivation (Rs/ha)** | **Gross Income****(Rs/ha)** | **Net Income****(Rs./ha)** | **B:C Ratio** |
|  |
| **Sowing date** |
| **(S1 )23 October** | 17.09 | 32.67 | 35698 | 73185 | 37487 | 1:2.05 |
| **(S2) 04th November** | 17.8 | 35.22 | 34860 | 76464 | 41604 | 1:2.19 |
| **(S3)14th November** | 16.22 | 30.94 | 33506 | 69446 | 35940 | 1:2.07 |
| **Bio-fertilizer** |
| **Organic Sulphur @ 40 kg/ha (D1)** | 15.43 | 30.5 | 35966 | 66277 | 30311 | 1:1.84 |
| **Organic Sulphur @ 40 kg/ha + Azotobacter (D2)** | 15.88 | 31.3 | 36808 | 68192 | 31384 | 1:1.85 |
| **Organic Sulphur @ 40 kg/ha +Phosphorus Solubilizing Bacteria (D3)** | 16.49 | 32.89 | 37670 | 70889 | 33219 | 1:1.88 |
| **Organic Sulphur @ 40 kg/ha + Sulphur Solubilizing Bacteria (D4)** | 17.5 | 35.09 | 37986 | 75268 | 37282 | 1:1.98 |
| **Organic Sulphur+ Azotobacter +Phosphorus Solubilizing Bacteria + Sulphur Solubilizing Bacteria (D5)** | 17.08 | 34.67 | 37005 | 73546 | 36541 | 1:1.98 |
| **Absolute control (D6)** | 14.9 | 30.65 | 35975 | 64240 | 28265 | 1:1.78 |

**Summary**

This study was undertaken to evaluate the effect of different sowing dates and bio-fertilizer treatments on the yield performance and economic returns of canola (Brassica napus). The field experiment consisted of three sowing dates—23rd October (S1), 4th November (S2), and 14th November (S3)—and six bio-fertilizer treatments, including combinations of organic sulphur and microbial inoculants (Azotobacter, PSB, and SSB).

**It concluded that:-**

* The **sowing date of 4th November (S2)** recorded the **highest grain yield (17.8 q/ha)** and **straw yield (35.22 q/ha)**, along with the **maximum gross income (Rs. 76,464/ha), net income (Rs. 41,604/ha)**, and **B:C ratio (1:2.19).** This indicated that S2 as the most suitable sowing date under the prevailing agro-climatic conditions.
* **Early sowing (S1)** also performed well but slightly lagged behind S2 in terms of yield and profitability. **Late sowing (S3)** resulted in the **lowest yield (16.22 q/ha)**, likely due to exposure to less favorable climatic conditions during key growth phases.
* Among bio-fertilizer treatments, **D4 (Organic Sulphur + SSB)** emerged as the most effective, yielding **17.5 q/ha** of grain and providing the **highest net income (Rs. 37,282/ha)** with a **B:C ratio of 1:1.98**.
* The integrated treatment **D5 (Organic Sulphur + Azotobacter + PSB + SSB)** also showed promising results with a grain yield of **17.08 q/ha** and a comparable economic return.
* The **control treatment (D6),** which did not include any bio-fertilizer, recorded the **lowest performance** in both yield and profitability, reinforcing the beneficial impact of bio-fertilizer application.
* Treatments D2 (OS + Azotobacter) and D3 (OS + PSB) also improved crop performance compared to the control, albeit to a lesser extent than D4 and D5.

**Conclusion:**

The study clearly revealed that both sowing time and bio-fertilizer application play a critical role in enhancing the yield and economic returns of canola cultivation. Sowing canola on **4th November**, combined with the application of **organic sulphur and sulphur solubilizing bacteria (D4)** or the **full microbial consortium (D5),** offers the most favorable outcomes in terms of both productivity and profitability. These results are in agreement with previous studies on rapeseed-mustard by Bhagat *et al.* (2024), Kaur *et al.* (2018), and Tyagi (2017), which stress the importance of synchronization between crop phenology and environmental conditions.

These results highlight the need for **timely agronomic management** and **biological nutrient inputs** in sustainable agriculture. The integration of appropriate sowing schedules with bio-fertilizer technology can serve as a cost-effective and eco-friendly approach to optimize canola production, ensuring better soil health and improved farm income. Adoption of these practices can significantly contribute to climate-resilient and sustainable oilseed farming systems.

Integrated use of organic sulphur and microbial consortia (D5) also offers sustainable productivity advantages in alignment with the results from studies by Meena *et al*. (2021) and Kaur *et al*. (2022). Thus, adoption of these agronomic strategies in Himalayan foothills and similar agro-ecological regions can ensure long-term economic and ecological benefits.

Disclaimer (Artificial intelligence)

Option 1:

1. Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, manuscript.

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