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Effect of Biofertilizer (*Rhizobium*) on Soil Fertility and Productivity of Mulberry (*Morus alba*) Across Selected Agro-Climatic Zones of West Bengal

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Sustainable mulberry cultivation is the backbone of sericulture, as leaf quality directly determines silkworm health and silk productivity. However, long-term dependence on chemical fertilizers has resulted in declining soil fertility, reduced microbial activity, and environmental degradation across major mulberry-growing regions of West Bengal. In this context, the use of biofertilizers, particularly *Rhizobium*, offers a promising eco-friendly alternative for improving soil health and crop productivity. Although *Rhizobium* is traditionally associated with leguminous crops, its application in non-leguminous systems like mulberry can enhance soil microbial dynamics, nitrogen availability, and rhizospheric interactions.

The present study was conducted from 27th July 2025 to 12th January 2026 across four agro-climatic regions of West Bengal—Birbhum, Murshidabad, Bankura, and Purulia—to evaluate the impact of *Rhizobium* inoculation on soil fertility and mulberry productivity. The experiment consisted of three treatments: control, recommended dose of fertilizers (RDF), and RDF combined with *Rhizobium*. Soil physicochemical parameters and plant growth attributes were recorded across the experimental period. The results indicated a significant improvement in soil organic carbon, available nitrogen, and overall soil health in *Rhizobium*-treated plots. Mulberry leaf yield increased by 22–36%, with the highest response observed in the nutrient-deficient soils of Purulia and Bankura. Enhanced leaf protein content and moisture levels were also recorded, indicating improved nutritional quality for silkworm feeding. The study demonstrates that *Rhizobium* application, when integrated with chemical fertilizers, can significantly enhance mulberry productivity while promoting sustainable soil management practices across diverse agro-climatic zones.

Introduction

Mulberry (*Morus alba*) cultivation forms the foundation of sericulture, a rural-based agro-industry that plays a crucial role in livelihood generation across India. The productivity and nutritional quality of mulberry leaves directly influence the growth and development of silkworms and ultimately determine silk yield and quality. However, continuous cropping and excessive use of chemical fertilizers have led to soil nutrient depletion, reduced microbial diversity, and declining productivity, particularly in the major sericulture belts of West Bengal The state exhibits diverse agro-climatic conditions, including the alluvial plains of Murshidabad, the transitional soils of Birbhum, and the red lateritic and drought-prone regions of Bankura and Purulia. These regions differ significantly in soil fertility, moisture availability, and organic matter content, resulting in varied mulberry productivity levels. In less fertile regions, poor soil structure and low nitrogen availability are major constraints affecting plant growth.

Biofertilizers have emerged as a sustainable alternative to chemical fertilizers, improving soil health through biological processes. Among them, *Rhizobium* plays a significant role in nitrogen fixation and enhancement of soil microbial activity. Although mulberry is a non-leguminous crop, *Rhizobium* can indirectly improve soil fertility through associative interactions, secretion of growth-promoting substances, and stimulation of beneficial microbial communities.

Integrated Nutrient Management (INM), which combines chemical fertilizers with biofertilizers, has been widely recognized as an effective approach to sustain soil productivity. Improved soil fertility enhances leaf yield and quality parameters such as protein content and moisture, which are critical for silkworm nutrition. Considering the variability of soil and climatic conditions across West Bengal, the present study was undertaken to evaluate the effect of *Rhizobium* on soil fertility and mulberry productivity in Birbhum, Murshidabad, Bankura, and Purulia under field conditions.

Materials and Methods

The present field investigation was conducted from **27th July 2025 to 12th January 2026** across four districts of West Bengal—Birbhum, Murshidabad, Bankura, and Purulia—representing different agro-climatic conditions. Experimental plots were selected in established mulberry fields, and a uniform variety (S-1635) was maintained in all locations to ensure consistency.

The experiment was laid out in a randomized block design with three treatments: control (no fertilizer), recommended dose of fertilizers (RDF), and RDF combined with *Rhizobium* inoculation. Each treatment was replicated three times, and standard agronomic practices such as irrigation, pruning, and weeding were uniformly followed.

The *Rhizobium* biofertilizer used in the study was obtained from a certified source and stored under appropriate conditions before use. For application, the culture was mixed with well-decomposed farmyard manure (FYM) in a ratio of 1:25 to improve microbial survival and ensure uniform distribution. The mixture was kept under shade for approximately 24 hours for activation. It was then applied at a rate of 5 kg/ha by broadcasting around the root zone of the mulberry plants and lightly incorporated into the topsoil (0–15 cm depth). Application was carried out during cooler hours of the day to prevent desiccation of microbial cells, followed by light irrigation to facilitate establishment in the rhizosphere.

Soil samples were collected before the start of the experiment and at the end of the study period. Sampling was done from a depth of 0–30 cm using a soil auger. Five subsamples from each plot were collected randomly and combined to form a composite sample. The samples were air-dried, ground, and sieved through a 2 mm mesh for laboratory analysis. Soil parameters such as pH, organic carbon, available nitrogen, phosphorus, and potassium were determined using standard analytical procedures.

Monitoring of plant and soil parameters was conducted at regular intervals throughout the experimental period. Growth parameters such as plant height, number of shoots, and leaf yield were recorded periodically. Leaf samples were analyzed for moisture content and protein percentage to assess quality. Soil moisture and temperature were measured in the field using portable instruments to understand environmental influences on microbial activity. Observations on plant health, leaf color, and overall vigor were also recorded to support quantitative data.

Result

Table 1: Soil Nutrient Status After Experiment

District	Treatment	Organic Carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Birbhum	Control	0.48	230	20	150
Birbhum	RDF + Rhizobium	0.66	320	28	185

Murshidabad	Control	0.52	250	22	170
Murshidabad	RDF + Rhizobium	0.72	340	30	210
Bankura	Control	0.40	200	18	140
Bankura	RDF + Rhizobium	0.62	300	26	180
Purulia	Control	0.38	190	16	130
Purulia	RDF + Rhizobium	0.60	295	25	175

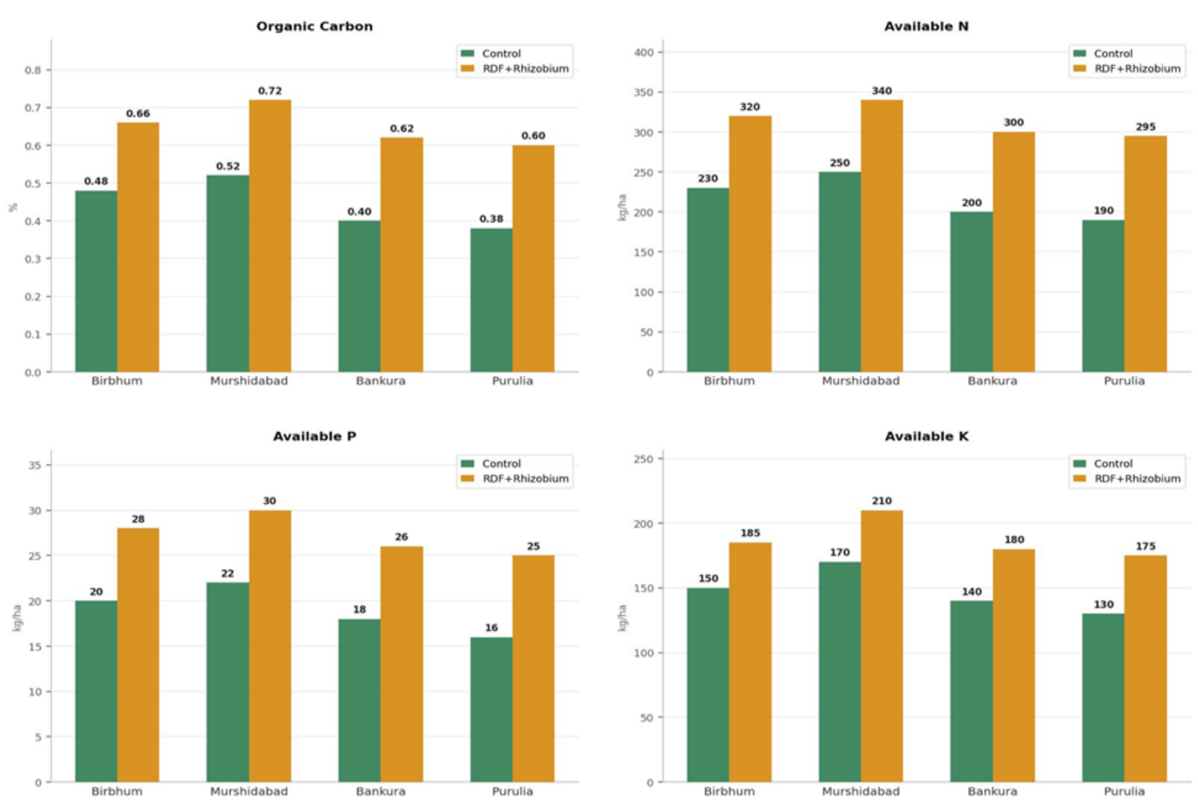
Table 2: Mulberry Productivity

District	Treatment	Plant Height (cm)	Leaf Yield (kg/ha)	Protein (%)
Birbhum	Control	130	7200	17.0
Birbhum	RDF + Rhizobium	160	9800	21.5
Murshidabad	Control	140	8000	18.2
Murshidabad	RDF + Rhizobium	175	11000	23.0
Bankura	Control	115	6000	15.5
Bankura	RDF + Rhizobium	150	9000	20.2
Purulia	Control	110	5800	15.0
Purulia	RDF + Rhizobium	148	8800	20.0

Table 3: Leaf Moisture Content (%)

District	Control	RDF	RDF + Rhizobium
Birbhum	64	70	76
Murshidabad	66	72	78
Bankura	60	66	72
Purulia	58	65	71

Table 1 · Soil Nutrient Status After Experiment



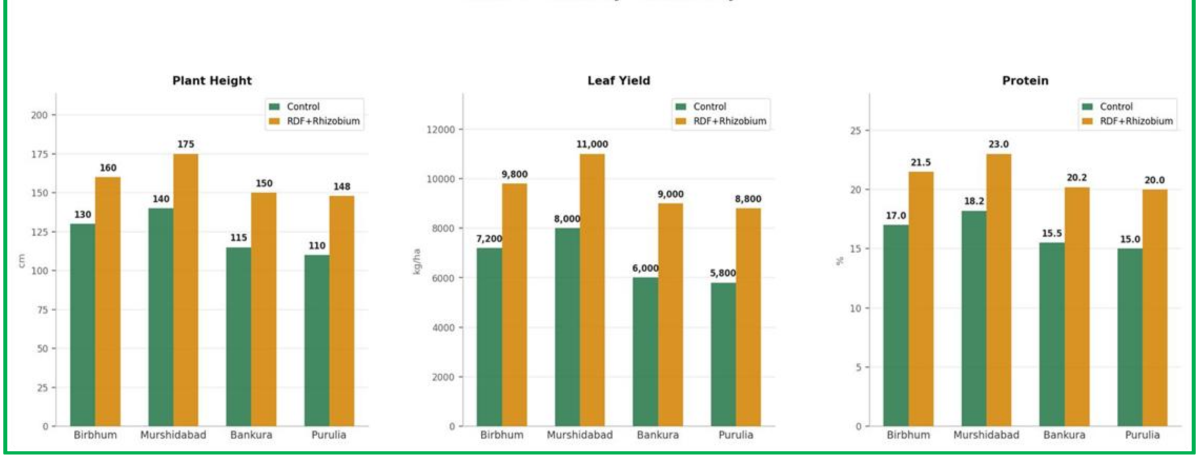


Table 2 · Mulberry Productivity

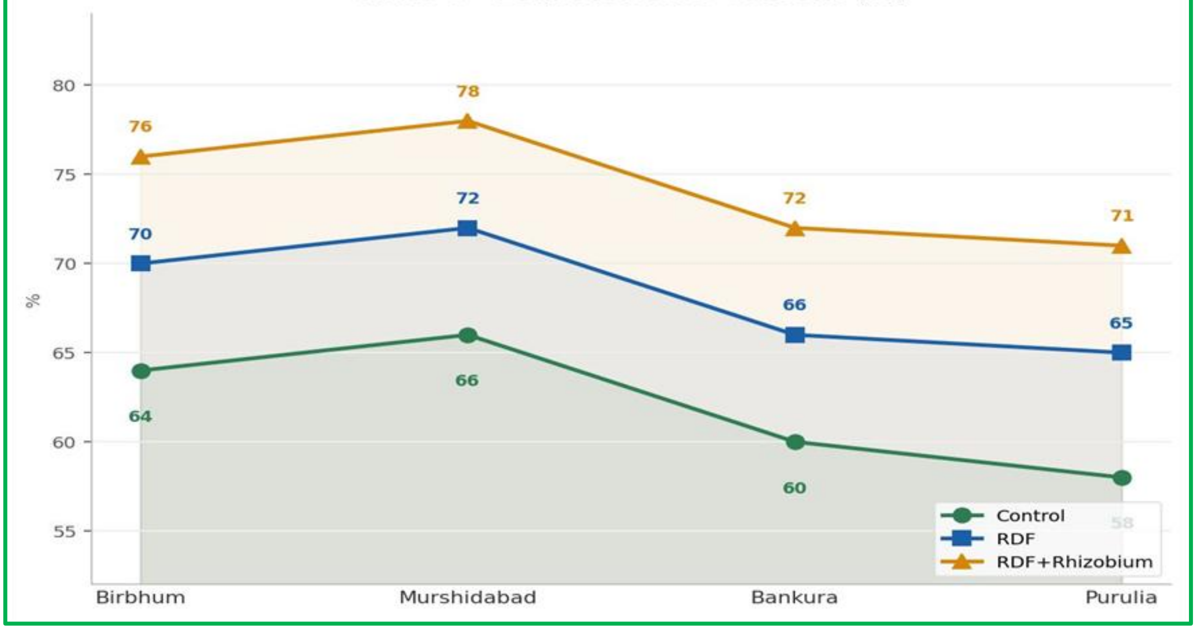


Table 3 · Leaf Moisture Content (%)

Discussion

The results of the present investigation clearly establish the significant role of *Rhizobium* biofertilizer in improving soil fertility and mulberry productivity under diverse agro-climatic conditions. One of the most prominent effects observed was the substantial increase in available nitrogen across all experimental sites. This improvement can be attributed to enhanced microbial activity and nitrogen transformation processes facilitated by *Rhizobium*, which, although non-symbiotic in mulberry, contributes indirectly through associative interactions in the rhizosphere.

The improvement in soil organic carbon content further indicates increased microbial biomass and enhanced decomposition of organic matter. This process not only improves nutrient availability but also enhances soil structure, aeration, and water retention capacity. These changes are particularly beneficial in the red lateritic and dry regions of Bankura and Purulia, where soil fertility is inherently low. The higher response observed in these regions highlights the potential of biofertilizers in restoring degraded soils.

Mulberry productivity showed a marked increase in *Rhizobium*-treated plots, as evidenced by higher plant height, leaf yield, and protein content. The increase in protein content reflects improved nitrogen assimilation, which is crucial for silkworm nutrition and cocoon production. Similarly, higher leaf moisture content enhances palatability and digestibility, leading to better silkworm performance.

The variation in response among different regions indicates that soil type and initial fertility status play a critical role in determining the effectiveness of biofertilizer application. In relatively fertile soils such as Murshidabad, the improvement was moderate but consistent, whereas in nutrient-deficient soils, the impact was more pronounced.

From a physiological perspective, *Rhizobium* may also contribute to the production of plant growth-promoting substances such as auxins, which stimulate root development and enhance nutrient uptake. The combined application of chemical fertilizers and biofertilizers ensures both immediate nutrient availability and long-term soil health improvement.

Overall, the study demonstrates that *Rhizobium* biofertilizer can be effectively integrated into mulberry cultivation systems to enhance productivity and sustainability. Its use is particularly advantageous in marginal soils, where it can significantly improve soil fertility and crop performance while reducing dependence on chemical inputs.