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Comparative Study of Green Gram Cultivation under Natural Farming and Recommended Practices in Villages of Gwalior, Madhya Pradesh[1]

Dr. Amita Sharma
Scientist Agroforestry, KVK, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior Madhya Pradesh, India
Dr. Lakhan Singh Mohaniya
Research fellow, Agronomy, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur, Madhya Pradesh, India
Dr. Gyanranjan Sahoo
Scientist, Agroforestry, KVK, Odisha University of Agriculture & Technology, Bhubaneswar, Odisha, India
Dr. Sharad Chandra Srivastava
STO Economics, KVK, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior Madhya Pradesh, India
Dr. Mukesh Bhargava
Scientist, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior Madhya Pradesh, India

Abstract

This research investigates the comparative effectiveness of green gram (Vigna radiata) cultivation under two distinct agricultural paradigms—natural farming and conventional recommended practices—in the semi-arid agro-climatic conditions of Rampur and Sahrai villages in Gwalior district, Madhya Pradesh. The natural farming system was based on Subhash Palekar's Zero Budget Natural Farming (ZBNF) model, which emphasizes the use of indigenous and eco-friendly inputs derived from cow-based formulations. Key components included Beejamrit for seed treatment to enhance germination and resistance to soil-borne diseases; Jeevamrit and Ghanjeevamrit as microbial-rich liquid and solid bio-inputs to enrich soil fertility and stimulate plant growth; and Neemastra, a botanical formulation, for the biological management of pests. In contrast, the recommended package of practices followed standard agronomic protocols involving the application of

[1]Address Author Correspondence to Dr. Amita Sharma
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synthetic fertilizers (NPK) and chemical pesticides for nutrient and pest management.

Field trials were conducted using a randomized block design to evaluate various agronomic and economic parameters including germination percentage, plant height at different growth stages, pest and disease incidence, overall yield per hectare, input cost, and net economic returns. The findings indicated that although the recommended practices yielded slightly higher grain output, the natural farming system showed a significant reduction in pest infestation and input costs. This resulted in a notably higher benefit-cost (B:C) ratio for the natural farming plots compared to those managed with conventional inputs.

These results highlight the potential of natural farming not only as an environmentally sustainable option but also as a cost-effective model particularly suited for smallholder and marginal farmers. The study concludes that adoption of ZBNF techniques can contribute to improving farm resilience, reducing dependency on external inputs, and promoting long-term soil health, thereby aligning with the broader goals of sustainable and inclusive agricultural development in India's dryland regions.

Keywords

Green gram cultivation, Zero Budget Natural Farming (ZBNF), Subhash Palekar, Natural farming, Green gram cultivation, Zero Budget Natural Farming (ZBNF), Subhash Palekar, Natural farming.

1. Introduction

Green gram (*Vigna radiata*), commonly known as moong, is one of the most important pulse crops cultivated across India. It is highly valued for its high protein content, soil-enriching properties due to nitrogen fixation, and short cropping duration, making it suitable for multiple cropping systems. In Madhya Pradesh, especially in the Gwalior district, green gram plays a crucial role in sustaining livelihoods, contributing to food security, and improving soil fertility in rainfed and semi-arid regions.

However, traditional and conventional agricultural practices have increasingly relied on chemical fertilizers, pesticides, and high-cost inputs to maximize yield. While these practices have led to short-term productivity gains, they have also resulted in long-term environmental degradation, reduced soil fertility, pest resistance, and increased the cost of cultivation. These trends pose challenges to the sustainability and profitability of small and marginal farming systems in India.

In response to these concerns, alternative farming approaches that are cost-effective, environmentally sustainable, and resource-efficient are gaining importance. One such approach is Zero Budget Natural Farming (ZBNF), developed by Padma Shri Subhash Palekar. ZBNF is a holistic, chemical-free farming method that aims to eliminate external input costs by promoting the use of locally available natural resources. It is based on four main formulations: *Beejamrit* (for seed treatment), *Jeevamrit* and *Ghanjeevamrit* (for soil nourishment and microbial activity), and *Neemastra* (for pest

control). These formulations are derived primarily from indigenous cow dung, cow urine, and plant-based inputs, making ZBNF not only sustainable but also accessible to smallholder farmers.

This research study was conducted to evaluate the performance of green gram cultivation under natural farming (ZBNF) practices compared to the conventional recommended package of practices in two selected villages—Rampur and Sahrai—in the Gwalior district of Madhya Pradesh. The objective was to assess key agronomic indicators such as germination rate, plant growth, pest incidence, yield, and economic returns to determine the viability of natural farming as a sustainable alternative.

By providing empirical evidence from field trials, this study aims to contribute to the ongoing discourse on sustainable agriculture and inform policymakers, researchers, and farming communities about the practical benefits and limitations of adopting natural farming methods, particularly in semi-arid agro-ecological zones.

2. Literature Review

Green gram (Vigna radiata) is a crucial legume crop in India, valued for its high protein content and nitrogen-fixing ability, which benefits soil fertility (Singh et al., 2016). Traditionally, its cultivation has relied on synthetic fertilizers and pesticides to enhance yield, but concerns over environmental degradation and input costs have motivated the search for sustainable alternatives (Kumar & Singh, 2018).

Natural Farming and Zero Budget Natural Farming (ZBNF)

Zero Budget Natural Farming, popularized by Subhash Palekar, advocates the use of locally prepared bio-inputs such as Beejamrit, Jeevamrit, Ghanjeevamrit, and Neemastra to maintain soil fertility and manage pests sustainably (Palekar, 2011). These formulations are based on cow dung, cow urine, and local resources that promote beneficial microbial activity and plant health without synthetic chemicals (Ramesh et al., 2017).

Several studies have demonstrated the positive impact of ZBNF on crop productivity and soil health. For example, Mishra et al. (2019) reported that crops grown under ZBNF showed improved microbial biomass and nutrient cycling compared to conventional farming. Similarly, Singh and Chauhan (2020) found that the use of Beejamrit for seed treatment enhanced germination rates and seedling vigor in pulses.

Use of Indigenous Bio-Inputs

Beejamrit, a microbial seed treatment, is documented to suppress seed-borne pathogens and improve seedling emergence (Kale et al., 2018). Jeevamrit and Ghanjeevamrit serve as nutrient-rich organic fertilizers that enhance soil organic matter and microbial diversity, thereby improving nutrient availability (Patil et al., 2020). Neemastra, a fermented neem-based pest repellent, has been effective in controlling sucking pests and caterpillars, reducing the reliance on synthetic pesticides (Joshi et al., 2019).

Comparative Studies on Natural vs Conventional Practices

Comparative trials have shown that while conventional farming often yields slightly higher productivity due to readily available synthetic inputs, natural farming systems provide benefits in terms of cost savings, pest resistance, and environmental sustainability (Sharma et al., 2021). For instance, Rao et al. (2022) observed that natural farming resulted in 10–15% lower yields but reduced input costs by nearly 50%, leading to better profit margins in pulse crops.

In Madhya Pradesh, where semi-arid conditions prevail, natural farming techniques have been linked to improved soil moisture retention and resilience against climatic variability (Verma & Singh, 2023). However, long-term studies are needed to fully understand the cumulative effects of ZBNF on soil fertility and crop yields.

Research Gap

Despite growing evidence supporting natural farming, limited research focuses specifically on green gram cultivation in the Gwalior region using the full spectrum of Subhash Palekar's bio-inputs. This study aims to fill this gap by systematically comparing ZBNF with recommended conventional practices, evaluating agronomic performance, pest management, and economic viability in real farm conditions.

3. Materials and Methods

3.1 Study Area

The field experiment was conducted during the Kharif 2024 cropping season in Rampur and Sahrai villages, located in the Gwalior district of Madhya Pradesh. These villages were selected based on their active involvement in pulse cultivation and the availability of farmers practicing both conventional and natural farming methods. "The geographical coordinates of the region lie approximately between 26.2° to 26.3° N latitude and 78.1° to 78.2° E longitude.

The area falls under Agro-Climatic Zone IV (Gird Zone) of Madhya Pradesh. The climate is semi-arid, with a monsoonal rainfall pattern, receiving annual precipitation between 600–800 mm, primarily between June and September. Temperatures range from 25°C to 45°C during the crop growth period. Soils in the study area are predominantly black cotton soils (Vertisols) with moderate fertility and good water retention, interspersed with alluvial soils in some patches—both of which are suitable for pulse crops like green gram. These agro-edaphic conditions provided an appropriate backdrop to assess the impact of natural and conventional practices on green gram productivity.

3.2 Experimental Design and Treatments

A Randomized Block Design (RBD) was employed to minimize environmental variability across the field and improve statistical validity. The study included two treatments and three replications in each village, making a total of 12 plots. Each plot was of uniform size, measuring 10 m × 10 m, with 1-meter buffer zones between plots to avoid cross-contamination of treatments.

The experiment involved the following treatments:

T1: Natural Farming (ZBNF-Based)

This treatment followed the guidelines of Subhash Palekar's Zero Budget Natural Farming (ZBNF) model, which is based on principles of sustainability, soil regeneration, and input cost minimization through locally available bio-inputs.

- **Seed Treatment:** *Beejamrit* was used, prepared by mixing 5 kg desi cow dung, 5 liters cow urine, 50 g lime, and a handful of bund soil in 20 liters of water. Seeds were dipped in the mixture for 30 minutes before sowing to enhance germination and protect against seed-borne pathogens.
- **Soil Enrichment:**
    - *Jeevamrit* was applied as a liquid microbial formulation at 15-day intervals, prepared using 10 kg cow dung, 10 liters cow urine, 2 kg jaggery, 2 kg pulse flour, and a handful of soil fermented in 200 liters of water for 48 hours.
    - *Ghanjeevamrit* (a solid version of Jeevamrit) was applied at sowing as a basal dose @ 200 kg/ha to improve microbial activity and nutrient availability in the root zone.
- **Pest Management:**
    - *Neemastra* was used as a biopesticide prepared from 5 kg neem leaves, 5 liters cow urine, 2 kg cow dung, and water, fermented for 48 hours. It was sprayed twice, at vegetative and pod initiation stages, to control sucking pests and leaf defoliators.
- **Other Practices:** No synthetic fertilizers, weedicides, or insecticides were applied. Weeding and other intercultural operations were done manually.

T2: Recommended Practices (Conventional Agriculture)

This treatment followed the Indian Council of Agricultural Research (ICAR)-recommended package of practices for green gram cultivation.

- **Seed Treatment:** Seeds were treated with Carbendazim 50% WP @ 2 g/kg to prevent fungal infections.
- **Fertilizer Application:** A basal dose of NPK was applied @ 20:40:20 kg/ha using urea, single super phosphate (SSP), and muriate of potash (MOP).
- **Pest Management:** Two rounds of chemical pesticide application were performed:
    - First with Monocrotophos 36 SL @ 1.5 ml/liter of water
    - Second with Imidacloprid 17.8 SL @ 0.3 ml/liter of water during flowering and pod filling stages.
- **Other Practices:** All other intercultural operations such as irrigation, thinning, and weeding were carried out uniformly across both treatments.

3.3 Crop and Variety

The crop selected for the study was green gram (*Vigna radiata*), variety IPM 02-3, which is a popular, short-duration, high-yielding variety recommended for the region. The seeds were sown using a seed drill at a spacing of 30 cm (row-to-row) × 10 cm (plant-to-plant), with a seed rate of 20 kg/ha. Sowing was done in the last week of June, and the crop was harvested in the third week of September.

3.4 Data Collection Parameters

To assess the comparative performance of the two farming systems, the following agronomic, plant health, and economic parameters were recorded:

- **Germination Percentage** (observed 10 days after sowing)
- **Plant Height** at 30 and 60 Days After Sowing (DAS)
- **Number of Pods per Plant** (at physiological maturity)
- **Pest and Disease Incidence** (% of plants affected)
- **Grain Yield** (kg/ha), recorded by harvesting from a demarcated net plot area and extrapolated
- **Cost of Cultivation** (INR/ha), including input, labor, and application costs
- **Gross Returns** (INR/ha), calculated based on local market rate of green gram at harvest
- **Net Returns** = Gross Returns − Cost of Cultivation
- **Benefit-Cost (B:C) Ratio** = Gross Returns ÷ Cost of Cultivation

For biometric observations (height, pods per plant, pest incidence), five plants were randomly selected from each plot. Yield was adjusted for moisture content to ensure uniformity.

3.5 Statistical Analysis

Data collected were subjected to statistical analysis using Analysis of Variance (ANOVA) under RBD to determine the significance of differences between treatments at the 5% level of significance ($p < 0.05$). The mean, standard deviation, and coefficient of variation were also computed. Economic parameters were analyzed through cost-benefit analysis to compare the financial viability of each method. The software MS Excel and OPSTAT were used for analysis and graphical representation of results.

4. Results and Discussion

This study compared the performance of green gram (Vigna radiata) cultivation under Zero Budget Natural Farming (ZBNF) and recommended conventional practices across two villages—Rampur and Sahrai—in the Gwalior district. The evaluation focused on key agronomic parameters, pest and disease incidence, yield, cost of cultivation, and economic returns. The detailed results and their implications are discussed below.

4.1 Germination Percentage

Seed germination is a critical initial stage that influences crop establishment and subsequent growth. The green gram seeds treated with Beejamrit, a bio-inoculant used in ZBNF, demonstrated a germination rate of 88.3%, which was marginally but consistently higher than the 85.6% observed in chemically treated seeds under conventional practices using Carbendazim.

This improved germination under ZBNF can be attributed to the microbial richness of Beejamrit, which contains beneficial bacteria and fungi that enhance seed vigor, promote root development, and suppress seed-borne pathogens. These microorganisms create a protective environment around the seed, improving moisture retention and nutrient availability during early growth. Such biological seed

treatments reduce the reliance on chemical fungicides, making the process safer and more eco-friendly.

Treatment	Germination Percentage (%)
Natural Farming (ZBNF)	88.3
Conventional	85.6

4.2 Plant Height

Plant height is an important indicator of vegetative growth and overall crop vigor. Measurements taken at 30 and 60 days after sowing (DAS) revealed that plants grown under conventional farming exhibited slightly greater height—27.4 cm at 30 DAS and 47.8 cm at 60 DAS—compared to 25.2 cm and 45.3 cm, respectively, under ZBNF.

The faster growth in conventional plots can be linked to the immediate availability of synthetic nutrients, particularly nitrogen, which directly supports shoot elongation. In contrast, the natural farming approach relies on gradual nutrient release through microbial activity and organic matter decomposition". Despite these differences, the variations in plant height were not statistically significant, indicating that both farming systems supported adequate vegetative growth suitable for healthy crop development.

Treatment	Plant Height at 30 DAS (cm)	Plant Height at 60 DAS (cm)
Natural Farming (ZBNF)	25.2	45.3
Conventional	27.4	47.8

4.3 Pest and Disease Incidence

One of the most striking benefits of ZBNF was its impact on pest management. The incidence of pests was significantly lower in natural farming plots (9.2%) compared to conventional plots (16.8%).

The regular application of Neemastra, a fermented neem-based bio-pesticide, played a crucial role in suppressing common pests such as aphids, whiteflies, and caterpillars. Neem contains natural insecticidal compounds that repel or disrupt pest feeding and reproduction without harming beneficial insects or the environment. Additionally, the enhanced microbial activity in the soil under ZBNF likely improved plant health and induced systemic resistance, further reducing vulnerability to pest attacks. By minimizing the need for chemical pesticides, ZBNF contributes to safer farming practices and environmental conservation.

Treatment	Pest Incidence (%)
Natural Farming (ZBNF)	9.2
Conventional	16.8

4.4 Number of Pods per Plant

Pod production directly influences the yield potential of legumes. The average number of pods per plant was slightly higher under conventional farming (28.6 pods) compared to natural farming (27.1 pods). However, this difference was minor and statistically insignificant, suggesting that the reproductive capacity of plants in both systems was comparable.

This result indicates that the bio-inputs used in ZBNF sufficiently met the nutrient requirements for flowering and pod development, thereby supporting reproductive success. It also highlights that natural farming can sustain the physiological processes of the crop effectively, despite the absence of synthetic nutrient supplementation.

Treatment	Pods per Plant
Natural Farming (ZBNF)	27.1
Conventional	28.6

4.5 Grain Yield

Yield is a critical outcome measure for any cropping system. The grain yield from conventional plots was 880 kg/ha, marginally higher than the 835 kg/ha achieved under ZBNF. Although the conventional method yielded about 5.4% more grain, the difference was not statistically significant, underscoring the potential of natural farming to produce near-comparable yields.

The slightly lower yield in ZBNF may be linked to the slower nutrient release rates inherent in organic systems and the relatively short duration of the study. However, natural farming's emphasis on soil health improvement suggests that yields could stabilize or increase over multiple seasons as soil fertility improves.

Treatment	Grain Yield (kg/ha)
Natural Farming (ZBNF)	835
Conventional	880

4.6 Cost of Cultivation

The cost analysis revealed a substantial reduction in expenses for ZBNF plots. The cost of cultivation under natural farming was INR 13,200/ha, compared to INR 21,500/ha in conventional farming. This cost savings mainly resulted from the use of on-farm prepared inputs like Beejamrit, Jeevamrit, and Neemastra, which eliminated the need for costly synthetic fertilizers, pesticides, and fungicides.

Lower input costs improve the economic accessibility of farming, particularly benefiting smallholder and marginal farmers who often face credit constraints. Additionally, reduced expenditure on agrochemicals diminishes financial risks linked to market price fluctuations.

Treatment	Cost of Cultivation (INR/ha)
Natural Farming (ZBNF)	13,200
Conventional	21,500

4.7 Economic Returns

Despite the marginally lower yield, natural farming generated higher net returns due to the significant reduction in input costs. The economic analysis showed:

Parameter	Natural Farming (ZBNF)	Conventional
Gross Return (INR/ha)	50,100	52,800

Net Return (INR/ha)	36,900	31,300
Benefit-Cost Ratio	2.8	2.45

The benefit-cost ratio (B:C) of 2.80 under ZBNF compared to 2.45 in the conventional system clearly indicates greater profitability and sustainability for natural farming. This improved economic viability, combined with environmental and health benefits, underscores ZBNF's suitability as a low-cost, high-return farming model.

4.8 Farmer Feedback and Sustainability

Farmers participating in the study expressed positive experiences with ZBNF. They reported improvements in soil texture, increased organic matter, better moisture retention, and easier field management due to fewer weed infestations and less dependency on chemical sprays. Importantly, farmers noted a decline in health problems commonly associated with chemical pesticide use, such as respiratory irritation and skin allergies.

These qualitative benefits enhance the long-term sustainability of natural farming by promoting safer working conditions, improving soil resilience, and encouraging ecological balance.

Summary

In summary, while conventional farming offered slightly higher vegetative growth and grain yield, natural farming delivered comparable productivity with significantly reduced input costs and pest pressure. The enhanced economic returns and environmental benefits observed with ZBNF endorse its adoption as a sustainable, cost-effective, and environmentally friendly alternative for green gram cultivation in semi-arid regions such as Gwalior. Continued promotion and research into natural farming methods could support the livelihood security of smallholder farmers while contributing to sustainable agricultural development

5. Conclusion

This study provides a comprehensive evaluation of green gram (Vigna radiata) cultivation under Subhash Palekar's Zero Budget Natural Farming (ZBNF) model, highlighting its practical viability and sustainability when compared to conventional agricultural methods reliant on synthetic inputs. By employing indigenous and biologically active formulations such as Beejamrit for seed treatment, Jeevamrit and Ghanjeevamrit for soil enrichment, and Neemastra for pest control, ZBNF represents a holistic approach rooted in ecological principles and traditional farming wisdom.

The field experiments conducted in Rampur and Sahrai villages of Gwalior district revealed that although the conventional farming system achieved slightly higher yields, the natural farming plots closely matched them in productivity. The differences in germination, plant growth, and pod development were marginal and statistically non-significant, suggesting that the nutrient and pest management approaches of ZBNF are sufficiently robust to support healthy crop growth even in semi-arid conditions.

Importantly, the ZBNF method demonstrated a clear advantage in reducing pest incidence and enhancing seed germination, outcomes likely driven by the microbial richness and bioactivity of the

natural formulations. These benefits translated into lower crop losses and reduced need for external chemical interventions, thereby strengthening the crop's resilience and minimizing health risks associated with agrochemicals.

From an economic standpoint, ZBNF proved to be significantly more cost-effective. The input costs were substantially lower due to the on-farm preparation and use of bio-inputs, leading to a higher net return and a superior benefit-cost ratio (2.80) compared to the conventional practice (2.45). For small and marginal farmers, this enhanced profitability is critical, as it reduces dependence on credit and external inputs, and improves income stability.

Additionally, qualitative feedback gathered from farmers practicing ZBNF pointed to improvements in soil texture, easier field management, and a noticeable reduction in health-related issues that are often associated with chemical pesticide use. These intangible benefits further underline the social and environmental value of natural farming.

In conclusion, this study affirms that natural farming under the ZBNF model is not only agronomically effective but also economically advantageous and environmentally sustainable. Its low-input, low-risk framework makes it especially suitable for semi-arid regions like Gwalior, where soil and water conservation are paramount. As a farming model, ZBNF aligns well with the goals of sustainable agriculture by promoting biodiversity, reducing chemical load, and enhancing farmer well-being.

To fully realize the potential of ZBNF, multi-seasonal research, continuous farmer training, and policy-level interventions are essential. Further studies should focus on long-term soil health, climate resilience, and crop diversification to build a strong scientific base for scaling natural farming initiatives across India and beyond.

6. Recommendations

Based on the findings from this comparative study of green gram cultivation under Zero Budget Natural Farming (ZBNF) and recommended conventional practices in Rampur and Sahrai villages of Gwalior district, the following recommendations are proposed to promote sustainable agriculture and enhance farmer livelihoods in semi-arid regions:

6.1 Promotion of Zero Budget Natural Farming (ZBNF) Practices

- Encourage wider adoption of ZBNF techniques such as the use of Beejamrit for seed treatment, Jeevamrit and Ghanjeevamrit for soil fertility enhancement, and Neemastra for eco-friendly pest management. These indigenous bio-inputs have proven effective in maintaining yield, reducing pest incidence, and lowering input costs.
- Government and agricultural extension agencies should organize regular training and demonstration programs for farmers, focusing on preparation and application of ZBNF formulations to build confidence and technical capacity.

6.2 Support for Small and Marginal Farmers

- ZBNF's low input cost and sustainable nature make it especially suitable for resource-poor smallholder farmers. Targeted support such as subsidies on raw materials for bio-inputs,

micro-credit facilities, and access to technical guidance can facilitate adoption and reduce financial risks.

- Promote farmer producer organizations (FPOs) or cooperatives to enable collective production and sharing of bio-inputs, reducing costs further and fostering community engagement.

6.3 Integration with Local Agro-Ecological Conditions

- Tailor ZBNF practices to local soil types, climate, and cropping patterns in Gwalior and similar semi-arid zones to maximize benefits. Encourage farmers to monitor soil health parameters and crop performance over time for adaptive management.
- Conduct multi-seasonal trials to refine application schedules and doses of bio-inputs for specific varieties and cropping systems.

6.4 Policy and Institutional Support

- Policymakers should recognize and incentivize natural farming approaches as part of sustainable agriculture frameworks and climate resilience strategies.
- Facilitate research and development programs that focus on improving indigenous formulations, understanding soil microbiomes, and integrating natural farming with modern scientific knowledge.
- Establish quality standards and certification mechanisms for bio-inputs like Beejamrit and Neemastra to ensure consistency and efficacy.

6.5 Environmental and Health Awareness

- Promote awareness campaigns about the health and environmental benefits of reducing chemical fertilizers and pesticides, highlighting ZBNF's role in minimizing pollution, preserving biodiversity, and enhancing farmer well-being.
- Encourage the adoption of natural farming to reduce the ecological footprint of agriculture and improve long-term soil fertility and water conservation.

6.6 Future Research Directions

- Conduct long-term studies to assess the cumulative effects of ZBNF on soil organic matter, microbial diversity, carbon sequestration, and climate change mitigation potential.
- Investigate the scalability of ZBNF in different crops and agro-ecological zones to develop region-specific guidelines.
- Explore integration of natural farming with modern precision agriculture technologies to optimize resource use efficiency.

These recommendations aim to support sustainable intensification of green gram cultivation and promote resilient farming systems that align with ecological principles and socioeconomic realities of farmers in Madhya Pradesh and similar regions.

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