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Novel year-round production technology of leaf lettuce through natural farming in Solan district of Himachal Pradesh

Solan is endowed with diverse agro-climatic conditions suitable for lettuce cultivation. Year-round production technology can be adopted to produce lettuce during the off-season, thereby generating higher returns for farmers. Lettuce is a cool-season, low nutrient-demanding crop and is inherently well suited to natural farming systems. Natural farming enhances crop productivity by reducing input costs and increasing farmers' net income, thereby promoting climate-resilient agriculture. Year-round production of leaf lettuce in hilly regions can be achieved by transplanting during February, April, August, and October. These planting windows ensure optimal growth, development, and yield throughout the year. Among the treatments evaluated, the combination of Ghanjeevamrit @ 1 t/ha + Jeevamrit drenching @ 15% + Saptadhanyankur @ 3% + sour buttermilk @ 3% significantly improved yield and quality by enhancing nutrient availability, microbial activity, and plant uptake. This treatment also resulted in the highest net returns and benefit–cost ratio, making it the most profitable option for year-round lettuce production.

Keywords: Ghanjeevamrit, *Jeevamrit,* Lettuce, Natural Farming

LETTUCE is a cool-season crop, and the favourable climate of Solan district makes it suitable for year-round cultivation. A major constraint in lettuce production is the sharp decline in prices due to market glut, which often results in economic losses for growers. Therefore, the development of year-round production technology is essential to ensure stable income for farmers.

Lettuce is a low nutrient-demanding crop and is inherently well suited to natural farming systems. Unlike many vegetable crops that require high levels of chemical fertilizers, lettuce performs well in soils enriched with organic matter and beneficial microorganisms. This makes natural farming an ideal and sustainable approach for lettuce cultivation, especially since lettuce is consumed raw and is increasingly popular due to changing dietary preferences.

Natural farming offers a "triple-win" opportunity by enhancing crop productivity, reducing input costs, and increasing farmers' net income, thereby promoting climate-resilient agriculture. It emphasizes soil biology over soil chemistry by encouraging practices such as multi-cropping, continuous soil cover, and the use of organic formulations prepared from cow dung and urine to stimulate microbial activity. These practices ultimately contribute to higher net returns and a better benefit–cost ratio, making natural farming a profitable option for year-round lettuce production.

Year round production technology under natural farming

The development of year-round production technology under natural farming involved four years of experimentation (2021–2024) at the experimental farm of KVK, Solan, located at Kandaghat, Himachal Pradesh. Observations were recorded for key plant and soil parameters. Different planting times and nutrient management strategies were evaluated to identify the most effective combinations for maximizing lettuce yield and quality while maintaining soil health. The major findings are summarized below:

- Transplanting of the leaf lettuce variety '*Solan Kriti*' during February, April, August, and October was found to be most suitable for ensuring optimal growth, development, and yield in a year-round production cycle. These months provide favourable climatic conditions that meet the crop's physiological requirements, highlighting the region's potential for continuous lettuce cultivation.
- The application of Ghanjeevamrit @ 1 t/ha + Jeevamrit drenching @ 15% + Saptadhanyankur @ 3% + sour buttermilk @ 3% significantly improved lettuce yield and quality, while also enhancing profitability due to reduced cost of cultivation. Natural farming practices were also found to support beneficial soil microorganisms and insects. Laboratory analyses

further confirmed improvements in soil health and crop quality.

- Benefit–cost analysis across different planting months demonstrated the economic viability of year-round lettuce production under natural farming systems.

Yield and productivity

The developed production technology resulted in significant improvements in yield and productivity. Trials conducted under natural farming systems showed better growth and higher yields compared to conventional chemical farming systems. Optimized agronomic practices, suitable lettuce varieties, and location-specific management strategies enabled consistent production, improved land-use efficiency, and enhanced overall productivity throughout the year.

The combined application of Ghanjeevamrit @ 1 t/ha + Jeevamrit drenching @ 15% + Saptadhanyankur @ 3% + sour buttermilk @ 3% showed superior performance for several parameters, including days to maturity, number of leaves per plant, leaf length, leaf breadth, plant height, fresh leaf weight, yield per plot, and micronutrient content (iron and calcium).

Pooled data over three years (2022–2024) for the variety '*Solan Kriti*' revealed that fresh leaf weight recorded during February, April, August, and October was 14.57 g, 13.31 g, 13.82 g, and 15.73 g, respectively, under M_3 level (Ghanjeevamrit @ 1 t/ha). Among liquid manures, L_4 (Jeevamrit drenching @ 15%) resulted in maximum fresh leaf weight (14.27 g, 12.92 g, 13.22 g, and 15.37 g, respectively).

The interaction effect (M_3L_4: Ghanjeevamrit @ 1 t/ha + Jeevamrit @ 15% + Saptadhanyankur @ 3% + sour buttermilk @ 3%) recorded the highest fresh leaf weight (14.34 g and 16.27 g during August and October, respectively), whereas the lowest values (9.22 g and 10.35 g) were observed under the control (M_1L_1) treatment (Table 1).

This improvement may be attributed to the synergistic effect of organic manures and liquid formulations, which enhance photosynthesis, energy storage, cell division, and cell enlargement, ultimately leading to increased fresh leaf weight.

Soil health parameters

Application of Ghanjeevamrit and natural liquid formulations (Ghanjeevamrit @ 1 t/ha + Jeevamrit drenching @ 15% + Saptadhanyankur @ 3% + sour buttermilk @ 3%) had a significant impact on soil microbial populations, including viable fungal, bacterial, and actinomycetes counts, which in turn enhanced nutrient uptake by plants.

The application of Ghanjeevamrit @ 1 t/ha + Jeevamrit drenching @ 15% recorded maximum N, P, and K uptake during different transplanting months, i.e., February (48.22, 16.79, 42.14 kg/ha), April (40.46, 14.94, 33.88 kg/ha), August (44.89, 15.71, 38.08 kg/ha), and October (52.32, 18.88, 46.12 kg/ha).

Cost effectiveness including B: C ratio

This technology is cost-effective due to optimized resource use, lower cost of cultivation, and higher productivity. By standardizing agronomic practices and improving yield consistency, it reduces input costs and enhances profitability. Its ability to ensure year-round production makes it a sustainable, high-return farming model suitable for both small and large-scale farmers.

Application of Ghanjeevamrit and natural liquid formulations significantly improved lettuce yield and overall crop equivalent yield, thereby enhancing the benefit–cost ratio. Among different transplanting months, the maximum B:C ratio was recorded in February (4.41) under treatment T_9 (Ghanjeevamrit @ 1 t/ha + Jeevamrit drenching @ 15%), followed by August (4.26) under T_{11} (Ghanjeevamrit @ 1 t/ha + Jeevamrit drenching @ 10%), October (3.73) under T_{12}, and April (3.69) under T_{12}.

SUMMARY

- Year-round, off-season production of lettuce can serve as a key strategy for crop diversification in Solan district, where farmers predominantly cultivate solanaceous crops (e.g., tomato and bell pepper), leading to a higher incidence of soil-borne diseases such as bacterial wilt. Diversification through the

Year Round Schedule developed for the cultivation of leaf lettuce

Sowing time	Transplanting Month	Harvesting Time	Key Observations
Late December to early January (under controlled conditions due to harsh winter)	February	March end to Ist week of April	Higher yield and good economic returns due to favorable growth conditions
Late February to March	April	May end (timely harvesting is critical as bolting may occur due to higher temperature)	Lower yield, but higher market prices as off season produce, ensuring profitability. Proper and timely irrigation is important to maintain optimum soil temperature.
Late June to July	August	September end to Ist week of October	Lower yield, but higher market prices as off season produce, ensuring profitability. Care should be taken for proper drainage due to rainy season.
Late August to September	October	December	Higher yield and good economic returns due to favorable growth conditions.

Leaf lettuce production in Solan district

introduction of exotic vegetables like lettuce is therefore essential in the mid-hill regions.

- Lettuce can be successfully transplanted in February, April, August, and October under year-round production systems, as these periods provide favourable agro-climatic conditions for optimal growth and development.
- Among natural farming practices, the treatment combination of Ghanjeevamrit @ 1 t/ha + Jeevamrit drenching @ 15% + Saptadhanyankur @ 3% + sour buttermilk @ 3% significantly improved yield and quality by enhancing nutrient availability, microbial activity, and plant uptake. Growth, yield, quality, and soil parameters were all superior under this treatment.
- The same treatment also resulted in the highest net returns and benefit–cost ratio, making it the most profitable option for year-round lettuce production. Among transplanting months, the highest benefit–cost ratio was recorded in February, followed by August, October, and April. While February and October plantings achieved higher yields and returns, April and August crops, despite relatively lower yields, fetched premium prices as off-season produce, highlighting the economic advantage of year-round production.

Overall, year-round lettuce production under natural farming systems offers a promising approach for enhancing farmer income and sustainability in the mid-hill regions of Himachal Pradesh.

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