Plant Archives Vol. 26, Supplement 2, 2026 pp. 3156-3162 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-2.402

SYNERGISTIC INFLUENCE OF NATURAL FARMING AND ORGANIC NUTRIENTS ON GROWTH AND YIELD PERFORMANCE OF LETTUCE (*Lactuca sativa* L.) IN THE MID-HILLS OF HIMACHAL PRADESH INDIA

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(Date of Receiving : 17-05-2026; Date of Revision : 30-06-2026; Date of Acceptance : 21-07-2026)

ABSTRACT

The present investigation entitled "Synergistic Influence of Natural Farming and Organic Nutrients on Growth and Yield Performance of Lettuce (*Lactuca sativa* L.) in the Mid-Hills of Himachal Pradesh (*Lactuca sativa* L.) "was carried out at the Research Farm of School of Agriculture, Abhilashi University, Mandi (H.P.) during the *rabi* season of year 2024. The experiment was laid out in randomized block design with 7 different treatments and 3 replications. Treatments include T_1 : Absolute control, T_2 : *Jeevamrit* drenching @5%, T_3 : FYM @ 10t/ha, T_4 : Vermicompost @5t/ha, T_5 : FYM @ 10t/ha + *Jeevamrit* drenching @ 5% T_6 : Vermicompost @ 5t/ha + *Jeevamrit* drenching @5%, T_7 : FYM @ 5t/ha + Vermicompost @ 2.5 t/ha + *Jeevamrit* drenching @ 5%. The results showed that maximum days taken to marketable maturity (42.56), leaf length (21.18 cm), leaf breadth (20.59 cm), plant height (25.93 cm), number of leaves per plant (28.13), fresh leaf weight (16.08 g), dry leaf weight (1.04 g), yield per plot (12.24 kg) and yield per hectare (256.17 q) were recorded in T_7 : FYM @ 5t/ha + Vermicompost @ 2.5t/ha + *Jeevamrit* drenching @ 5%. This treatment was followed by treatment T_6, while minimum values of observations were recorded under treatment T_1 (Absolute control). The soil pH ranges from 5.5 to 5.8. Treatment T_7 recorded maximum electrical conductivity (0.48dS/m) and maximum organic carbon (0.55%) in T_6. While maximum available nitrogen (305.52 kg/ha), phosphorous (14.23 kg/ha) and potassium (248.37 kg/ha) were observed in treatment T_7 (FYM @ 5t/ha + Vermicompost @ 2.5 t/ha + *Jeevamrit* drenching @ 5%). The maximum gross (Rs. 7,68,510/ha), net returns (Rs. 5,52,626/ha) and highest B: C ratio (3.56) was also obtained in treatment T_7.

Keywords **:** Lettuce, *Jeevamrit*, Vermicompos**t,** Nutrients.

Introduction

Lettuce (*Lactuca sativa* L.) is one of the most important vegetables grown at a commercial scale and is preferred worldwide for consumption due to its unique flavour. It is an annual leafy herb, belonging to the family Compositae and sub-family Chicoridae. It is believed to be originated in the Mediterranean region, Central Asia and South-West Asia. The cultivation of lettuce as a food crop originates from ancient Egypt, where it was initially used for its oil-rich seeds and later for its leaves. The Romans then adopted lettuce cultivation, giving it the name "lectuca," from which the English word "lettuce" is derived. Lettuce is mostly used in soups and salads, though it is sometimes delicately cooked renowned for its mildly bitter taste and delicate, crunchy texture (Squire *et al*. 1987).

Lettuce is one of the most economically important leafy vegetable crop in the world. Lettuce varieties include crisphead (like Iceberg), butterhead, loose-leaf and romaine. Lettuce is relatively easy to grow, thriving in cool temperature with moderate watering. The temperature best suited for the cultivation of lettuce is 18°C-25°C during day time and 10-15 during night (Ryder 1998; Lindquist 1960).

Lettuce offers numerous health benefits due to its rich nutrient profile. Lettuce is rich in vitamin A and minerals like calcium and iron. Lettuce also contains antioxidants and fiber, which contributes to overall well-being. It also contains protein, carbohydrates, and vitamin C and 100 g of the edible portion of lettuce contains 0.09 mg thiamine, 0.13 mg riboflavin, 0.3 g fat, 0.5 g fibre, 1.2 g minerals, 2.1 g protein, 2.5 g carbohydrates, 2.6 mg iron, 10.0 mg vitamin C, 80 mg phosphorus, 93.4 g moisture, 310 mg calcium, and about 1650 I.U. vitamin A (Gopalan and Balaraman 1966). Also for promoting hydration, aiding in weight management, and supporting healthy vision and bone health. In the process of modernization, particularly after the green revolution the consumption of chemicals namely fertilizers, pesticides, growth regulators, etc., has increased substantially in the production system. In order to achieve the current demand for food requirements, farmers are relying more on chemical fertilizers to achieve higher productivity per unit area. However, the efficiency of the chemical fertilizers already reached a plateau due to their indiscriminate and inefficient use and resulting in poor soil fertility status of the agriculture fields in addition to the accumulation of toxic substances in the harvested produces.

The utilization of Farm Yard Manure and natural liquid organic manures plays an important role in preserving soil health and crop productivity. Liquid natural manures contain essential macronutrients, micronutrients, and growth-promoting agents that, when applied to crops via foliar spray or soil drenching, stimulate plant growth and development, resulting in enhanced crop yields. The application of natural liquid manure such as *jeevamrit* which leads to increased crop growth and yield, along with improving soil physico-chemical and biological properties. These natural liquid manures are rich sources of growth-promoting substances like IAA, GA, essential vitamins, amino acids, beneficial microorganisms, and vital macro and micronutrients that foster plant growth (Devakumar *et al*. 2014). Organic and natural farming practices eliminate reliance on agrochemicals, emphasizing the use of natural products to enhance environmental sustainability and farm economics through increased yields and returns. Organic and natural farming can significantly contribute to maximizing lettuce production profitability while improving soil fertility (Uddin *et al*. 1995).

Material and Methods

Experimental site

The present investigation was carried out at Research Farm, School of Agriculture, Abhilashi University, Mandi (H.P.) during the summer season of 2023. The Experimental site is located at 31º33’32’’N latitude and 77º00’40” E longitude with the elevation of 1,432 m amsl.

Table 1: Treatment details

Treatments	Treatments
T_1	Absolute control
T_2	*Jeevamrit* drenching @ 5%
T_3	FYM @ 10 t/ha
T_4	Vermicompost @5t/ha
T_5	FYM@ 10t/ha + *Jeevamrit* drenching @ 5 %
T_6	Vermicompost @ 5t/ha+ *Jeevamrit* drenching @5%
T_7	FYM@ 5 t/ha + Vermicompost @ 2.5 t/ha + *Jeevamrit* drenching @ 5%

Design of experiment

The experiment was laid out in Randomized Block Design with three replications comprising seven treatment combinations of natural farming and organic nutrients. The layout plan is provided below:

Variety	**Romaine**
Design	Randomized Block Design (RBD)
Replications (s)	3
Treatments	7
Plot size	1.50 m× 1.50 m = 2.25m^2
Spacing	45 cm× 30 cm
Date of sowing	16th November, 2024
Date of transplanting	8th January, 2025

Observation recorded

Crop Studies

Five plants were randomly selected and tagged from each plot and observations were reported on the following characters.

Growth and Yield parameters

Days taken to marketable maturity

The number of days taken from the day of transplanting to the date when more than half of the population in each plot had attained the marketable size.

Leaf length (cm)

Leaf length of lettuce was recorded with the help of metric scale by measuring the length of lettuce leaves from the five randomly selected plants from each replication.

Leaf breadth (cm)

The breadth of the leaves was recorded with the help of the metric scale from the five randomly selected plants and recording their mean value.

Plant height (cm)

Plant height was measured with the help of measuring scale from five randomly selected plants from each replication including the stalk of the plant.

Number of leaves per plant

Total number of leaves per plant was counted from five randomly selected plants from each plot and their average value was recorded.

Fresh leaf weight (g)

Fresh leaf weight is the weight of leaf at marketable maturity. Fresh leaf weight was measured on the electronic weighing balance from the five randomly selected plants of lettuce from each plot and replication.

Dry leaf weight (g)

Dry leaf weight is the weight recorded after drying the leaf at temperature higher than the ambient temperature to drive off the water. Dry leaf weight was measured on the electronic weighing balance.

Yield per plot (kg) and yield per hectare (q)

Yield per plot was calculated using five randomly selected plants from the plot and weighed using electronic balance and the data was recorded which was further multiplied with total number of plants in the plot.

Soil Parameters

Soil pH

Soil pH was determined in 1:25 soil to water suspension after stirring the contents intermittently for half an hour. The pH value was recorded the application glass electrode method (Jackson, 1967).

Electrical conductivity of soil (dSm^{-1})

The electrical conductivity of soil was determined in 1:2 soil water suspensions the application glass electrode digital EC meter (Jackson 1973).

Organic carbon content of soil (%)

Organic carbon or easily oxidizable organic carbon of soil samples were determined by Walkley and Blacks wet oxidation method. The soil (0.5mm sieved) was treated with chromic acid to oxidize organic cars on to Co_2 and untreated $K_2Cr_2O_7$ was back titrated against standard ferrous ammonium sulphate. The application diphenylamine indicator (Jackson, 1967). Organic carbon content in the soil is expressed as percent.

Available N (kg/ha)

The alkaline potassium permanganate method (Subbaiah and Asija1956) was used to calculate the amount of available nitrogen in the soil (kg/ha). This involved digesting, distilling, and collecting NH_3 in 2% boric acid and titrating it against standard sulphuric acid.

Available P (kg/ha)

Olsen's extractant was used to determine the available phosphorus level, which was then measured at 660 nm wavelength using a NUKES UV-VIS spectrophotometer (Olsen *et al*., 1954**)**

Available K (kg/ha)

The amount of available potassium in the soil (kg/ha) was measured using a flame photometer after being extracted with neutral 1 N ammonium acetate (Merwin and Peech, 1951).

Economics

On the basis of current labor, organic manure, irrigation, and other expense rates, the cost of cultivation for each treatment was estimated per hectare. The average market price for lettuce at whole sale determined the total income per acre. After subtracting the treatment cost, the net profit per hectare was calculated.

Cost of cultivation (Rs. ha)

By presuming the item-wise input cost based on the local market rate, the cost of cultivation per hectare of land was worked out and were computed treatment-wise also.

Gross returns (Rs. /ha)

From the total yield of each treatment plot, the gross monetary return was worked out based on the average selling price of the product and it was recorded accordingly in Rs./ha.

Gross return (Rs. /ha) = Market price × Yield/ha

Net returns (Rs./ha)

The most crucial factor to consider before recommending any remedies to farmers for widespread use is their economic viability. The cost of cultivation for each treatment was deducted from the gross return from the economic yield to determine the net return. Net returns (Rs./ha) are calculated as follows:

Net returns (Rs./ha) = Gross returns (Rs./ha) - Cost of cultivation (Rs./ha)

Benefit cost ratio

Benefit cost ratio were worked out for each nutrient treatment by adopting the following formula:

$$\text{Benefit : Cost Ratio} = \frac{\text{Net returns (Rs./ha)}}{\text{Cost of cultivation (Rs. /ha)}}$$

Result and Discussion

Growth studies

The maximum days taken to marketable maturity (48.46) were recorded in treatment T_1 (Absolute control). The maximum leaf length (21.18 cm), maximum leaf breadth (20.59 cm), maximum plant height (25.93 cm) and maximum no. of leaves per plant (28.13) were recorded in treatment T_7 (FYM@ 5 t/ha + Vermicompost @ 2.5 t/ha + *Jeevamrit* drenching @ 5%). However, the minimum days taken to marketable maturity (42.56) were observed in treatment T_7. The minimum leaf length (12.77 cm), minimum leaf breadth (12.22 cm), minimum plant height (18.19 cm) and minimum no. of leaves per plant (1956) were observed in T_1 (Absolute control). The days taken to reach harvest maturity may have no direct influence on crop yields, but the variation may be associated with the nutritional status of the soil. The results related to this character of plant were influenced by varying levels of organic manures and natural liquid manures. Their combined application recorded the minimum number of days taken to first harvest as compared to other treatments. The reduction in the number of days may be attributed to added supply of nutrients and proliferous root system developed early under balanced nutrient application resulting in better absorption of water and nutrients with improved physical environment (Rather *et al*., 2018; Chatterjee, 2015). Average leaf breadth was significantly influenced by combined effect of different organic manures and natural liquid manures. This might be due to the continuous nutrient availability to the plants by the use of organic and natural liquid manures. This was found to be in accordance with findings of Hasan and Solaiman (2013), Sevinc *et al*. (2018) and Caliskan *et al*. (2014). Increasing plant height might be due to the reason that organic manure enhanced soil aggregation, aeration, water holding capacity and amended the root system by flow of nutrients, which in combination created favourable conditions for root respiration, nutrient absorption by the roots and hence growth in plant height. Ansari 2008; Sharma and Aggarwal, 2019).

Yield studies

The yield parameter was influenced by both natural farming and organic nutrients. The maximum fresh leaf weight (16.08 g), maximum dry leaf weight (1.04 g), maximum yield per plot (12.24 kg) and maximum yield per ha (256.17 q) were observed in treatment T_7 (FYM@ 5 t/ha + Vermicompost @ 2.5 t/ha + *Jeevamrit* drenching @ 5%). On the other hand, the minimum fresh leaf weight (9.67 g), minimum dry leaf weight (0.73 g), minimum yield per plot (8.64 kg) and minimum yield per ha (126.52 q) were recorded in treatment T_1 (Absolute control). Increasing fresh and dry leaf weight might be due to the fact that organic manures, natural liquid manures and their interaction enhances the role of leaves in photosynthesis, energy storage, cell division and cell enlargement (Singh, 2004; Durak *et al*., 2017). The increase in yield under higher treatments might be attributed to improved nutrient availability, better vegetative growth and enhanced photosynthetic activity, which ultimately resulted in greater biomass production and higher economic yield (Frasetya *et al*., 2019; Sharma *et al*., 2002).

Soil studies

Available N, P and K (Kg/ha)

The maximum amount of available nitrogen (305.52 kg/ha), available phosphorous (14.23 kg) and available potassium (248.37 kg) was recorded in treatment T_7 (FYM@ 5 t/ha + Vermicompost @ 2.5 t/ha + *Jeevamrit* drenching @ 5%). However, the minimum amount of available nitrogen (229.19 kg), available phosphrous (13.11 kg) and available potassium (192.51 kg) was measured in T_1 (Absolute control). The increase in available nitrogen due to organic matter application is also attributable to the greater multiplication of soil microbes caused by the addition of organic manures which mineralize organically bound N to inorganic form (Bellakki and Badanur, 1997). The organic manures decreases phosphorus adsorption or fixation and enhance phosphorus availability in phosphorus-fixing soils (Kumar *et al*., 2001). The increment in available potassium in soils might be associated with the direct addition of potassium to the available reserve of the soil with the application of organic and natural liquid

manures. The beneficial effect of natural manures on the available potassium might be due to the reduction of potassium fixation (Tandon, 1988).

Soil pH, EC and OC

The soil pH varied from 5.5-5.8. The highest electrical conductivity (0.48 dS/m) in soil was observed in treatment T_7 (FYM@ 5 t/ha + Vermicompost @ 2.5 t/ha + *Jeevamrit* drenching @ 5%) while the highest organic carbon (0.55 %) in soil was observed in treatment T_6 (Vermicompost @ 5t/ha+ *Jeevamrit* drenching @5%). However, the lowest organic carbon content (0.48%) was recorded in T_1 (Absolute control). The build-up of soil organic carbon with the application of organic manures may be attributed to additional carbon inputs resulting from the return of crop residues into soils. Soil organic carbon has been reported significantly higher in treatments involving organic nutrient sources (Swarup and Yaduvanshi, 2000).

Economics

The highest cost of cultivation (Rs. 2,15,884), gross returns (Rs. 768510), net return (Rs. 552626) and B: C ratio (3.56) was recorded highest under treatment T_7 (FYM@ 5 t/ha + Vermicompost @ 2.5 t/ha + *Jeevamrit* drenching @ 5%) whereas the lowest cost of cultivation was found in T_1 (Absolute control) i.e. (Rs. 145339). The minimum gross returns (Rs. 379560), net returns (Rs. 234221) and B: C ratio (2.61) was incurred in T_1 (Absolute control) respectively. Excellent vegetative growth and good soil conditions resulted in higher yield which ultimately led to the increase in economic yield, total gross income, net returns and benefit cost ratio despite of increase in expenditure. It was also reported that there was no losses due to insect and pest attack and no disease incidence was reported during the investigation interval (Patel *et al*., 2008).

Conclusion

Based on the present study, the application of FYM @ 5 t/ha + Vermicompost @ 2.5 t/ha + *Jeevamrit* drenching @ 5% proved to be the most effective treatment, exhibiting superior performance in terms of growth parameters, yield, yield-attributing traits, net returns, and benefit-cost ratio. This integrated nutrient management approach not only enhanced plant vigor and productivity but also improved soil health by promoting better nutrient availability and microbial activity.

Table 2 : Initial soil chemical properties

Sr.No.	Parameters	Values obtained	Method of analysis
1.	Soil pH	5.4	Glass electrode method (Jackson, 1967)
2.	Electrical conductivity (dS/m)	0.31	Electrical conductivity meter 1:2 soil water suspension (Jackson, 1973)
3.	Organic carbon (%)	0.47	Rapid titration method (Walkely and Black, 1934)
4.	Available N (kg/ha)	220.50	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
5.	Available P (kg/ha)	12.90	Olsen's Method of Extraction With 0.5 $NaHCO_3$ at pH 8.5 (Olsen *et al*., 1954)
6.	Available K (kg/ha)	190.20	Ammonium acetate extraction method (Merwin and Peech, 1950)

Table 3 : Conjoint effect of natural farming and organic nutrients on days taken to marketable maturity, leaf length (cm), leaf breadth (cm), plant height (cm), number of leaves per plant.

Treatment code	Treatment details	Days taken to marketable maturity	Leaf length (cm)	Leaf breadth (cm)	Plant height (cm)	Number of leaves per plant
T_1	Absolute control	48.64	12.77	12.22	18.19	19.56
T_2	*Jeevamrit* drenching @ 5%	46.24	13.62	14.75	20.43	21.22
T_3	FYM @ 10 t/ha	45.06	14.70	15.82	22.45	22.96
T_4	Vermicompost @5t/ha	44.08	17.55	16.79	23.29	24.85
T_5	FYM@ 10t/ha + *Jeevamrit* drenching @ 5 %	43.73	17.70	17.09	24.45	25.65
T_6	Vermicompost @ 5t/ha+ *Jeevamrit* drenching @5%	42.70	19.42	18.27	24.45	26.45
T_7	FYM@ 5 t/ha + Vermicompost @ 2.5 t/ha + *Jeevamrit* drenching @ 5%	42.56	21.18	20.59	25.93	28.13
	SE(m) (±)	**0.78**	0.25	0.19	0.25	0.34
	CD (P=0.05)	**2.42**	0.79	0.59	0.77	1.10

Table 4 : Conjoint effect of natural farming and organic nutrients on fresh leaf weight (g), dry leaf weight (g), yield per plot (kg) and yield per ha (q)

Treatment code	Treatment details	Fresh leaf weight (g)	Dry leaf weight (g)	Yield per plot (kg)	Yield per ha (q)
T_1	Absolute control	9.67	0.73	8.64	126.52
T_2	*Jeevamrit* drenching @ 5%	10.58	0.78	9.13	148.88
T_3	FYM @ 10 t/ha	11.66	0.85	9.48	170.78
T_4	Vermicompost @5t/ha	12.46	0.91	10.65	189.32
T_5	FYM@ 10t/ha + *Jeevamrit* drenching @ 5 %	14.60	0.99	11.04	202.93
T_6	Vermicompost @ 5t/ha+ *Jeevamrit* drenching @5%	14.95	1.01	11.34	224.84
T_7	FYM@ 5 t/ha + Vermicompost @ 2.5 t/ha + *Jeevamrit* drenching @ 5%	16.08	1.04	12.24	256.17
	SE(m) (±)	0.22	0.01	0.19	3.18
	CD (P=0.05)	0.69	0.04	0.59	9.80

Table 5 : Conjoint effect of natural farming and organic nutrients on available N, P and K, soil pH, electrical conductivity (dS/m) and organic carbon (%).

Treatment code	Treatment details	Soil pH	Electrical conductivity (dS/m)	Organic carbon (%)	Available nitrogen (kg/ha)	Available phosphrous (kg/ha)	Available potassium (kg/ha)
T_1	Absolute control	5.5	0.40	0.48	229.19	13.11	192.51
T_2	*Jeevamrit* drenching @ 5%	5.6	0.41	0.50	245.38	13.15	217.62
T_3	FYM @ 10 t/ha	5.6	0.42	0.50	258.84	13.21	223.28
T_4	Vermicompost @5t/ha	5.7	0.43	0.51	288.70	13.98	239.80
T_5	FYM@ 10t/ha + *Jeevamrit* drenching @ 5 %	5.6	0.45	0.51	279.97	13.66	234.42
T_6	Vermicompost @ 5t/ha+ *Jeevamrit* drenching @5%	5.7	0.46	0.55	293.25	14.11	241.76
T_7	FYM@ 5 t/ha + Vermicompost @ 2.5 t/ha + *Jeevamrit* drenching @ 5%	5.8	0.48	0.51	305.52	14.23	248.37
	SE(m) (±)	0.07	1.68	0.008	3.84	0.23	3.29
	CD (P=0.05)	NS	NS	0.02	11.84	0.71	9.98

Table 6 : Economics

Treatment code	Treatment details	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio
T_1	Absolute control	145339	379560	234221	2.61
T_2	*Jeevamrit* drenching @ 5%	160764	446640	285876	2.78
T_3	FYM @ 10 t/ha	179894	512340	332446	2.85
T_4	Vermicompost @5t/ha	185339	567960	382621	3.06
T_5	FYM@ 10t/ha + *Jeevamrit* drenching @ 5 %	190754	608790	418036	3.19
T_6	Vermicompost @ 5t/ha+ *Jeevamrit* drenching @5%	208037	674520	466483	3.24

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