



RESEARCH ARTICLE

Long-term effects of sustainable farming systems on carbon footprint, energy use efficiency and productivity of wheat (*Triticum aestivum* L.) varieties under subtropical conditions

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Abstract

With increasing emphasis on sustainable agricultural practices, understanding their long-term impacts on crop productivity, resource-use efficiency and environmental sustainability has become essential. The experiment was conducted at Krishi Vigyan Kendra, Jammu during the rabi seasons from 2020–21 to 2024–25 to evaluate the long-term effects of sustainable farming systems on carbon budgeting, energy indices and productivity of different wheat varieties under the subtropical conditions of Jammu region. The study was laid out in a factorial randomised block design with 3 replications comprising 12 treatment combinations. Two factors were evaluated: the first factor consisted of four wheat varieties (JAUW-584, JAUW-672, DBW-222 and HD-3237) whereas the second factor included integrated nutrient management (INM), organic farming and natural farming. The results revealed that the wheat variety HD-3237 under INM recorded higher dry matter accumulation, grain yield, yield sustainability index, production efficiency, nutrient uptake, carbon sustainability index, net returns and benefit-cost ratio along with the lowest carbon footprint. In contrast, HD-3237 under organic farming exhibited higher soil organic matter, greater carbon sequestration and the lowest bulk density. Among the energy indices, HD-3237 under natural farming recorded the highest energy productivity and energy-use efficiency along with the lowest input energy requirement. Overall, the wheat variety HD-3237 under INM recorded the highest grain yield, nutrient uptake, carbon sustainability index and benefit-cost ratio. However, HD-3237 under organic farming resulted in higher soil organic carbon and carbon sequestration whereas the same variety under natural farming recorded the highest energy productivity and energy-use efficiency.

Keywords: carbon sequestration; energy productivity; integrated nutrient management; natural farming; organic farming

Introduction

Sustainable agriculture production along with maintaining soil fertility has become one of the top priorities in intensive cereal-based cropping systems (1). In this context, wheat (*Triticum aestivum* L.) crop holds a strong position in the Indian and global markets because of its significant contribution to food security, nutritional supply and farmer's livelihood (2). However, the continuous use of chemical fertilisers leads to a decline in essential soil nutrients, decreased crop productivity and a reduced human lifespan (3). The long-term use of inorganic inputs can have adverse effects on soil physical properties, the microbial population and overall ecosystem of the Earth. To address these challenges, several alternative management approaches have begun to gain importance, such as integrated nutrient management (INM), organic farming and natural

farming (4, 5). Integrated nutrient management consists of the balanced use of inorganic fertilisers, organic manures and biofertilisers to improve soil health and crop production. Organic farming and natural farming focus mainly on maintaining ecological balance, promoting the biological nutrient cycle, minimising the use of chemical inputs and achieving long-term soil restoration (6, 7).

Different wheat varieties were studied to understand their responses to INM, organic farming and natural farming (8). Some varieties perform better with chemical fertilisers, while others adapt well to organic and natural farming because of differences in their nutrient use efficiency, growth habit, maturity period and other characteristics (9). In this way, the different varieties were sown to analyse their growth, yield and stability under different nutrient management systems.

In this context, growing concerns about environmental sustainability and the proper assessment of agricultural practices in terms of energy use and carbon emissions from machinery, labour, agricultural input and crop production have gained significant importance. Energy indices help in evaluating the efficiency and productivity of input use while the carbon indices, such as the carbon footprint and carbon sustainability index are used to quantify the environmental impact by crop production systems (10, 11). Thus, this study was conducted to evaluate the yield attributes, energy indices, carbon budgeting and soil fertility of different wheat varieties under different nutrient management systems to identify the most sustainable combination.

Materials and Methods

The study was conducted at the crop cafeteria, Krishi Vigyan Kendra, Jammu, during the rabi seasons from 2020–21 to 2024–25. The soil at the experimental site was sandy clay loam in texture, neutral in pH, low in organic carbon (4.37 g/kg), low in available nitrogen (239.56 kg/ha), medium in available phosphorus (13.23 kg/ha) and medium in available potassium (169.34 kg/ha). The crop was planted at a spacing of 22.5 x 10 cm with a plot size of 5 x 10 m.

The recommended dose of fertilisers (RDF) for the crop was nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) (NPK) at a ratio of 120:60:40 kg/ha. This experiment was laid out in factorial randomised block design (FRBD) with 3 replications comprising twelve treatment combinations. In this study, two factors were considered, first factor was variety in which four varieties of wheat were taken (JAUW-584, JAUW-672, DBW-222 and HD-3237) and second factor was nutrient systems comprising INM, organic farming and natural farming (Table 1). The treatments represented different farming systems which were evaluated based on their recommended management practices rather than on equivalent nutrient application. This study did not include any control or check variety. Irrigation was provided as required by the crop and generally applied once a week. Among the varieties, DBW-222 had the shortest duration of 120 days whereas JAUW-672 had the longest duration of 150 days to harvest. However, the other two varieties JAUW-584 and HD-3237 took 145 days to reach harvest. For weed management, pre-emergence application of pendimethalin (1 kg a.i./ha) followed by hand weeding at 30–35 days after sowing (DAS) under INM; two

Table 1. Treatment details of the field study

Factor A (Varieties)
JAUW-584
JAUW-672
DBW-222
HD-3237
Factor B (Nutrient management systems)
Integrated nutrient management (INM)
Organic farming
Natural farming

hand weedings at 25 and 45 DAS were carried out under organic farming and mulching with crop residue was practised under natural farming. The different nutrient system treatments were as follows:

Integrated nutrient management (INM): farmyard manure 6 t/ha + vermicompost 3 t/ha + 50 % recommended dose of fertilisers

Organic farming: farmyard manure 12 t/ha + vermicompost 3 t/ha + 0.5 % seaweed extract as a foliar spray

Natural farming: beejamrit 10 mL/kg seed + jeevamrit 500 L/ha + mulching with crop residue at 5 t/ha

The monthly meteorological data recorded during the crop growth period of the rabi season (November–April) from 2020–21 to 2024–25 at Krishi Vigyan Kendra, Jammu, Jammu and Kashmir are presented in Fig. 1. The weather conditions remained within the normal range for the region despite minor year-to-year variations. The temperature ranged from 4.3–37.9 °C, while the relative humidity varied from 20–97 %. Although slight seasonal fluctuations in temperature and relative humidity were observed, no abnormal weather events or extreme climatic conditions occurred during the crop growing seasons. Therefore, the prevailing weather conditions were generally favourable for crop growth and development and the treatment effects were evaluated under comparable environmental conditions across all 5 years.

The observations recorded included growth attributes, yield parameters, energy indices, carbon metrics, soil properties, nutrient uptake and relative economics. The growth and yield parameters comprised plant height, dry matter accumulation, effective tillers, spike length, grains per spike, grain yield, straw yield, yield sustainability index, production efficiency and harvest index. The energy indices included the input energy (MJ/ha), output energy

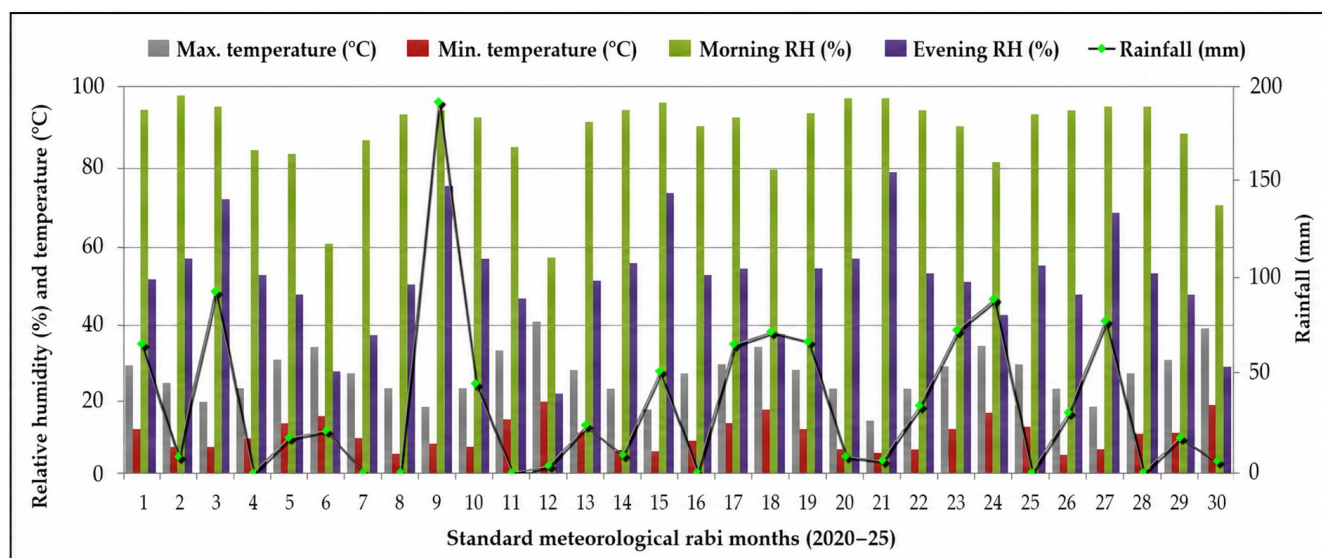


Fig. 1. Graphical representation of the meteorological data of wheat crop during rabi seasons of November–April (2020–25).

(MJ/ha), net energy, energy intensiveness, energy productivity and energy use efficiency were recorded (12). The carbon metrics comprised, the carbon input (kg CO₂ eq/ha), carbon output (kg CO₂ eq/ha), net carbon gain, carbon efficiency, carbon sustainability index and carbon footprint. The conversion factors used for calculating the various energy and carbon indices are presented in Table 2. Soil properties studied included organic carbon, nutrient status, bulk density and carbon sequestration. Total uptake by grain and straw was assessed under nutrient uptake. The relative economic analysis included cost of cultivation, gross returns, net returns and benefit-cost ratio. The various carbon, energy and productivity indices along with their formulae are given below:

Table 2. Energy and carbon equivalents of various agricultural inputs and outputs

Sl. No.	Particular	Unit	Energy equivalent (MJ/unit)	Carbon equivalents (kg CO ₂ /unit)	References
Inputs					
1.	Human labour	hr	1.96	0.03	(12)
2.	Diesel	L	56.31	0.94	(12)
3.	Farm machinery	hr	62.70	0.89	(12)
4.	Water	m ³	1.02	0.17	(12)
5.	Nitrogen (N)	kg	60.60	1.30	(12)
6.	Phosphorus (P ₂ O ₅)	kg	11.10	0.20	(12)
7.	Potassium (K ₂ O)	kg	6.70	0.15	(12)
9.	Wheat seed	kg	14.70	0.11	(12)
Outputs					
11.	Grain yield	kg	14.70	0.11	(12)
12.	Straw yield	kg	12.50	0.44	(12)

Net energy (MJ/ha) = output energy of treated plot- input energy of treated plot

$$\text{Energy intensiveness (MJ/₹)} = \frac{\text{input energy (MJ/ha)}}{\text{cost of cultivation (₹/ha)}}$$

$$\text{Energy productivity (kg/MJ)} = \frac{\text{economic yield (kg/ha)}}{\text{energy input (MJ/ha)}}$$

$$\text{Energy use efficiency (MJ)} = \frac{\text{output energy (MJ/ha)}}{\text{input energy (MJ/ha)}}$$

Net carbon gain (kg CO₂ eq/ha) = Carbon output - carbon input

$$\text{Carbon efficiency} = \frac{\text{carbon output (kg CO}_2 \text{ eq/ha)}}{\text{carbon input (kg CO}_2 \text{ eq/ha)}}$$

net carbon gain (kg CO₂ eq/ha)

$$\text{Carbon sustainability index} = \frac{\text{net carbon gain (kg CO}_2 \text{ eq/ha)}}{\text{carbon input (kg CO}_2 \text{ eq/ha)}}$$

$$\text{Carbon footprint (kg CO}_2 \text{ eq/kg)} = \frac{\text{carbon input (kg CO}_2 \text{ eq/ha)}}{\text{economic yield (kg/ha)}}$$

Carbon sequestration (Mg C/ha/year) = soil organic carbon (%) x bulk density (g/cm³) x soil depth (cm) x 0.1

$$\text{Yield sustainability index} = \frac{\text{average grain yield - standard deviation}}{\text{maximum grain yield}}$$

$$\text{Production efficiency (kg/ha/day)} = \frac{\text{grain yield (kg/ha)}}{\text{duration of crops (days)}}$$

Statistical analysis

The data recorded over 5 consecutive years were pooled after testing for the homogeneity of error variances. Statistical analysis were performed using analysis of variance (ANOVA) and the significance of the main effects of treatments, varieties and their interactions was evaluated using the F-test. The significance of differences among treatment means was determined at the 5 % probability level and the critical difference was calculated for mean comparisons (13). All statistical analyses were performed using OPSTAT software.

Results

Growth and yield parameters

The results revealed that higher plant height, dry matter accumulation (243.96 and 253.00 g/m²), effective tillers (291.72 and 319.01/m²), spike length, grains per spike, grain yield (3878 and 3989 kg/ha), straw yield (4682 and 5236 kg/ha), yield sustainability index (0.89, 0.93) and production efficiency (26.74 and 28.77 kg/ha/day) were recorded in the variety of HD-3237 under INM (Figs. 2–4). However, these parameters did not differ significantly among the varieties and nutrient management systems as the interaction between varieties and treatments remained non-significant (Table 3).

Nutrient uptake

The observed results showed that the higher uptake of nitrogen by grain and straw (59.14 and 23.14 kg/ha), phosphorus (14.79 and 4.85 kg/ha) and potassium (18.48 and 55.49 kg/ha) was recorded in the variety HD-3237. Among the nutrient management systems, the higher uptake of nitrogen (60.00 and 24.53 kg/ha), phosphorus (15.00 and 4.92 kg/ha) and potassium (18.75 and 58.53 kg/ha) was recorded under INM. The interaction between varieties and treatments was non-significant (Table 4).

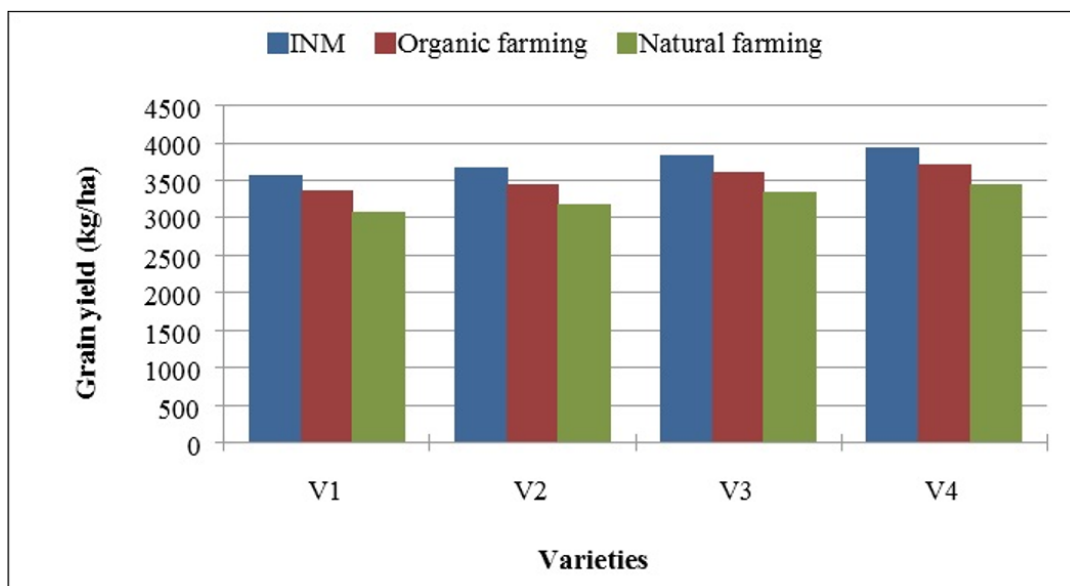


Fig. 2. Effect of wheat varieties and nutrient management systems on grain yield (pooled data of five years).

INM: Integrated nutrient management.

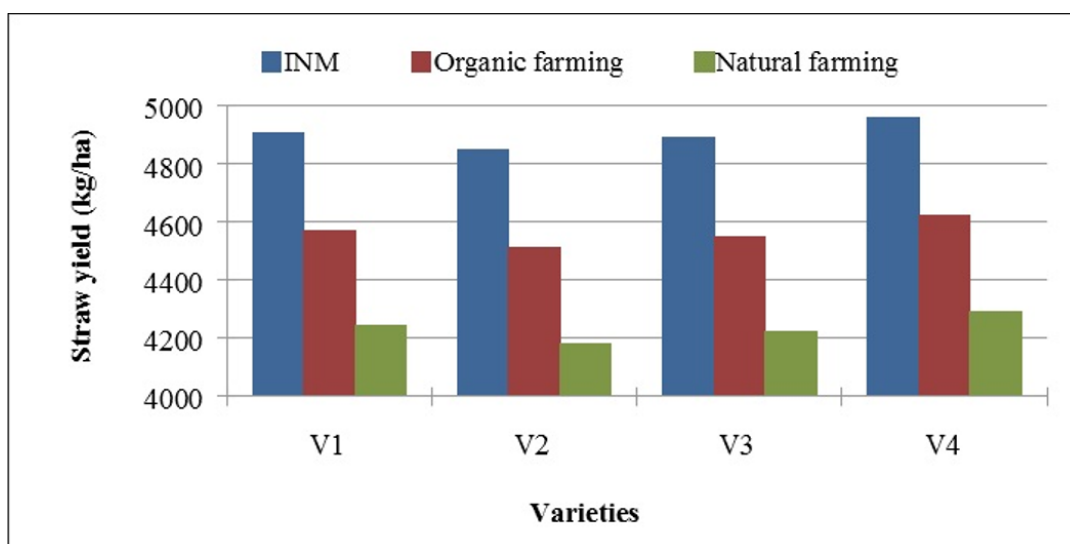


Fig. 3. Effect of wheat varieties and nutrient management systems on straw yield (pooled data of five years).

INM: Integrated nutrient management.

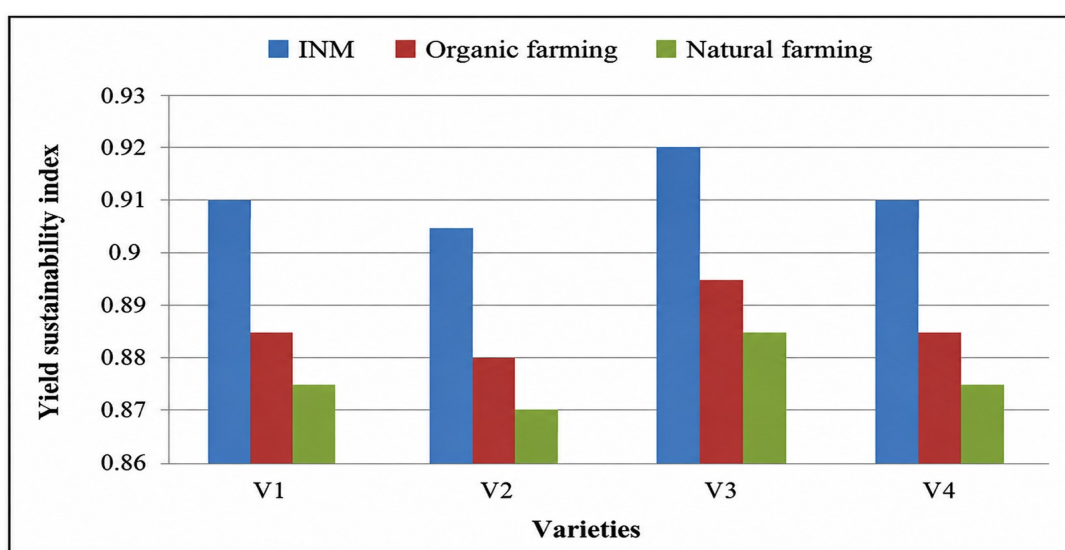


Fig. 4. Effect of wheat varieties and nutrient management systems on yield sustainability index (pooled data of five years).

INM: Integrated nutrient management.

Table 3. Effect of wheat varieties and nutrient management systems on growth and yield parameters (pooled data of five years)

Treatments	At 60 days after sowing						At harvest				
	Plant height (cm)	Dry matter accumulation (g/m ²)	Effective tillers/m ²	Spike length (cm)	Grains per spike	1000 grain weight	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)	Yield sustainability index	Production efficiency (kg/ha/day)
JAUW-584	36.60	217.12	266.82	10.35	48.11	38.34	3151	4583	40.74	0.89	21.73
JAUW-672	34.75	188.69	286.04	11.09	50.63	39.58	3350	4461	42.88	0.88	22.33
DBW-222	40.10	227.18	277.74	10.23	46.58	38.75	3678	4542	44.74	0.91	30.65
HD-3237	42.23	243.96	291.72	11.12	51.10	39.92	3878	4682	45.31	0.89	26.74
SEm (±)	0.37	3.20	4.07	0.11	0.44	0.76	40.10	96.85	-	-	-
CD (5 %)	1.10	9.59	12.15	0.33	1.30	NS	117.60	290.52	-	-	-
INM	42.86	253.00	319.01	11.69	53.82	41.35	3989	5236	43.24	0.93	28.77
Organic farming	38.23	225.54	278.47	10.62	49.39	39.28	3544	4560	43.74	0.88	25.61
Natural farming	34.16	179.17	244.26	9.79	44.11	36.82	3008	3905	43.52	0.86	21.72
SEm (±)	0.40	2.57	6.83	0.13	0.42	0.81	50.92	113.98	-	-	-
CD (5 %)	1.16	7.67	14.10	0.37	1.25	NS	152.76	334.31	-	-	-
Interaction (V x T)	NS	NS	NS	NS	NS	NS	NS	NS	-	-	-

INM: Integrated nutrient management.

Table 4. Effect of wheat varieties and nutrient management systems on nutrient uptake by grain and straw of crop (pooled data of five years)

Treatment	Nitrogen (kg/ha)			Phosphorus (kg/ha)			Potassium (kg/ha)		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
JAUW-584	53.33	22.87	76.20	13.33	4.59	17.92	16.67	54.49	71.16
JAUW-672	54.93	22.58	77.51	13.73	4.53	18.26	17.17	54.18	71.35
DBW-222	57.54	22.79	80.33	14.39	4.57	18.96	17.98	54.64	72.62
HD-3237	59.14	23.14	82.28	14.79	4.85	19.64	18.48	55.49	73.97
SEm (±)	0.54	0.21	0.75	0.13	0.07	0.27	0.41	0.67	0.77
CD (5 %)	1.06	0.44	3.56	0.27	0.21	0.57	0.85	1.38	1.02
INM	60.00	24.53	84.53	15.00	4.92	19.92	18.75	58.83	77.58
Organic farming	56.47	22.84	79.31	14.12	4.57	18.69	17.65	54.87	72.52
Natural farming	52.18	21.56	73.34	13.05	4.22	17.27	16.31	54.67	70.98
SEm (±)	0.45	0.18	0.65	0.12	0.05	0.23	0.35	0.61	0.79
CD (5 %)	0.92	0.39	2.34	0.25	0.14	0.47	0.74	1.24	1.62
Interaction (V x T)	NS	NS	NS	NS	NS	NS	NS	NS	NS

INM: Integrated nutrient management.

Soil studies

The results showed that the higher soil organic carbon (0.46 and 0.65 %), available nitrogen (195.66 and 265.23 kg/ha), available phosphorus (18.64 and 26.26 kg/ha), available potassium (132.83 and 178.04 kg/ha), carbon sequestration (0.69 and 1.32 Mg C/ha) and lower bulk density (1.05 and 1.35 g/cm³) at harvest were recorded in the variety HD-3237 under organic farming (Fig. 5). These soil parameters did not show any significant interaction between varieties and nutrient management systems (Table 5).

Energy indices

The results showed that the highest output energy (115532 MJ/ha), net energy (104858 MJ/ha), energy productivity (0.363 kg/MJ), energy use efficiency (10.82 MJ), lowest input energy (10674 MJ/ha) and energy intensiveness (0.315 MJ/₹) were recorded in the variety HD-3237. Among the nutrient management systems higher energy productivity (0.248 kg/MJ), energy use efficiency (7.68 MJ), lower input energy (12108 MJ/ha) and energy intensiveness (0.347 MJ/₹) were recorded under natural farming whereas higher output energy (124088 MJ/ha) and net energy (103892 MJ/ha) were recorded under INM (Table 6, Fig. 6).

Carbon budgeting

The results showed that the higher carbon output (2487 and 2743 kg CO₂ eq/ha), net carbon gain (1556 and 1603 kg CO₂ eq/ha), carbon efficiency (2.67 and 2.41), carbon sustainability index (1.67 and 1.41) and lower carbon footprint (0.24 and 0.29 kg CO₂ eq/kg) were recorded in the variety HD-3237 under INM (Table 7, Fig. 7).

Relative economics

In relative economics, the higher gross returns (₹86385/ha), net returns (₹52497/ha) and benefit-cost ratio (1.55) were recorded in the variety HD-3237. Among the nutrient management systems, the higher gross returns (₹121424/ha), net returns (₹75374/ha) and benefit-cost ratio (1.64) were recorded under INM (Table 8).

Discussion

The superior performance of HD-3237 in terms of growth, yield and nutrient uptake may be attributed to its better tillering ability, higher biomass production and more efficient utilisation of available nutrients than the other varieties. Enhanced nutrient absorption and translocation resulted in improved crop growth and dry matter accumulation, which ultimately translated into higher grain and straw yields. Among nutrient management systems, integrated INM recorded significantly higher growth, yield and nutrient uptake owing to the balanced and continuous supply of nutrients through the combined application of organic and inorganic sources. Improved nutrient availability and root activity under INM further enhanced nutrient use efficiency and biomass production. However, the relatively higher yield sustainability index and production efficiency observed in DBW-222 may be due to its shorter crop duration, greater yield stability and better adaptability under varying environmental conditions (14–20).

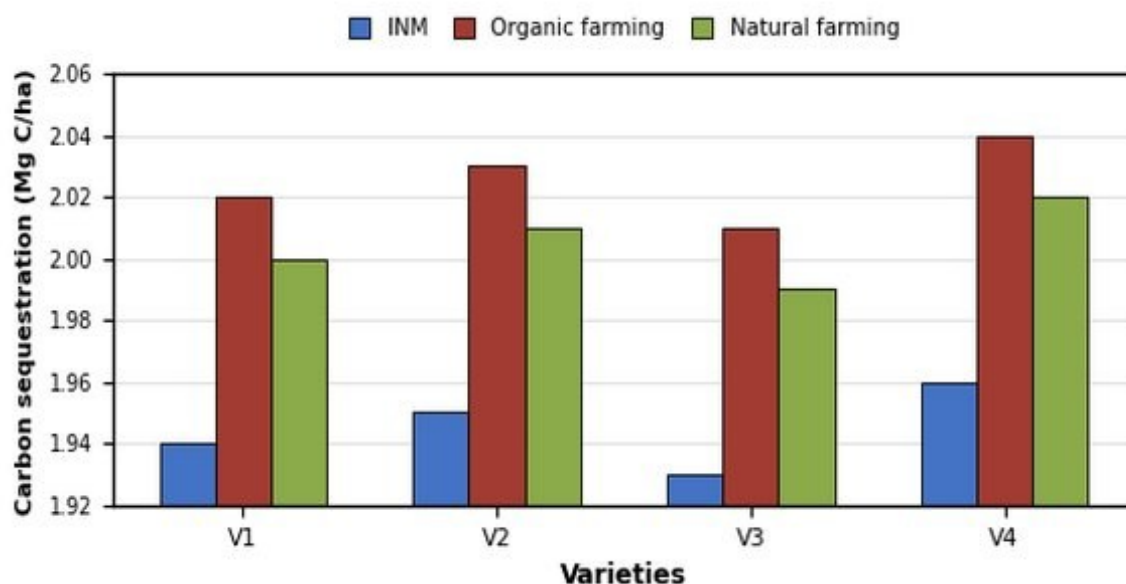


Fig. 5. Effect of wheat varieties and nutrient management systems on carbon sequestration (pooled data of five years).

INM: Integrated nutrient management.

Table 5. Effect of wheat varieties and nutrient management systems on soil properties (pooled data of five years)

Treatments	Organic carbon (%)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Bulk density (g/cm ³)	Carbon sequestration (Mg C/ha)
JAUW-584	0.44	192.21	17.81	129.24	1.06	0.70
JAUW-672	0.45	193.98	18.14	130.92	1.05	0.71
DBW-222	0.43	190.48	17.51	128.57	1.07	0.69
HD-3237	0.46	195.66	18.64	132.83	1.05	0.72
SEm (±)	0.02	1.54	0.43	2.22	0.06	-
CD (5 %)	NS	NS	NS	NS	NS	-
INM	0.50	250.52	23.03	162.52	1.65	1.24
Organic farming	0.65	265.23	26.26	178.04	1.35	1.32
Natural farming	0.62	261.59	25.81	174.00	1.40	1.30
SEm (±)	0.03	1.74	0.54	2.67	0.07	-
CD (5 %)	0.09	5.22	1.63	8.03	0.22	-
Interaction (V x T)	NS	NS	NS	NS	NS	-

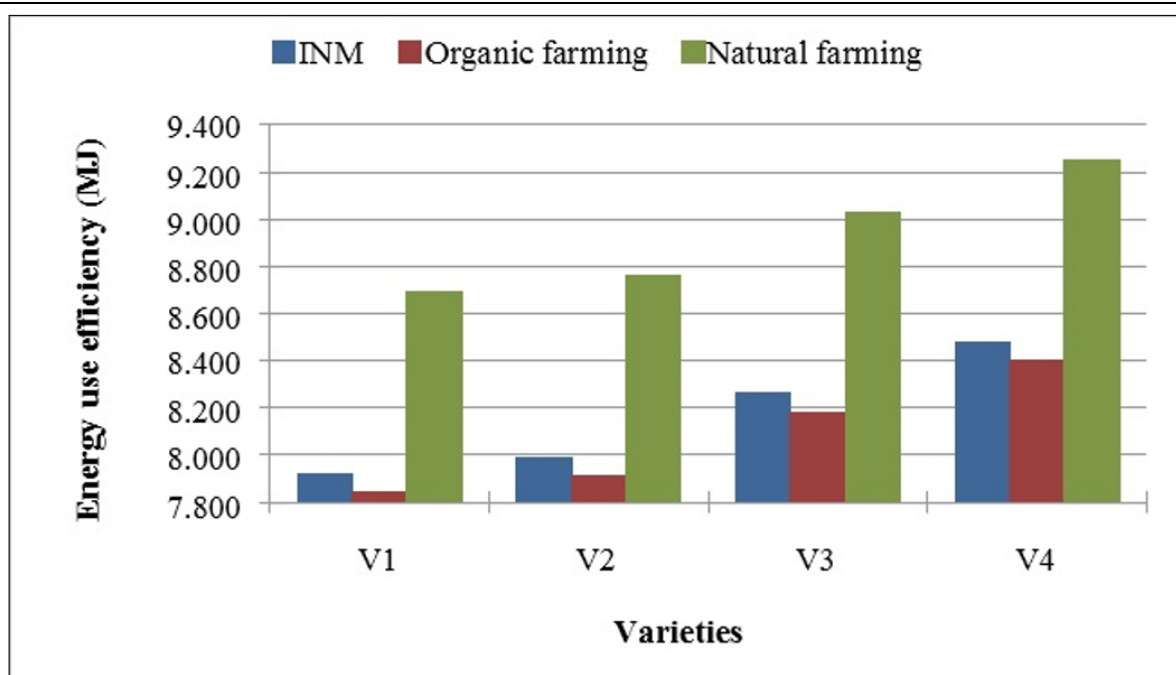


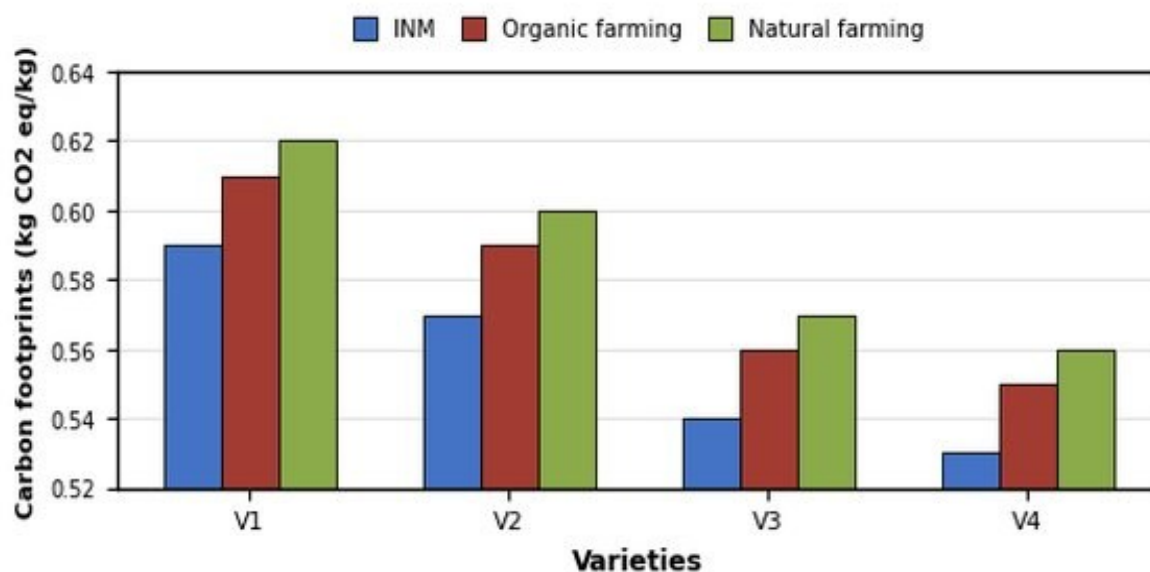
Fig. 6. Effect of wheat varieties and nutrient management systems on energy use efficiency (pooled data of 5 years).

INM: Integrated nutrient management.

Table 6. Effect of wheat varieties and nutrient management systems on energy indices (pooled data of 5 years)

Treatments	Input energy (MJ/ha)	Output energy (MJ/ha)	Net energy (MJ/ha)	Energy intensiveness (MJ/₹)	Energy productivity (kg/MJ)	Energy use efficiency (MJ)
JAUW-584	10676	103607	92931	0.320	0.295	9.70
JAUW-672	10674	105008	94334	0.318	0.314	9.84
DBW-222	10675	110842	100167	0.321	0.345	10.38
HD-3237	10674	115532	104858	0.315	0.363	10.82
INM	20196	124088	103892	0.439	0.198	6.14
Organic farming	18245	109097	90852	0.357	0.194	5.98
Natural farming	12108	93030	80922	0.347	0.248	7.68

MJ: Mega Joule; Common Input Energy in transplanted rice: 10674 MJ/ha; INM: Integrated nutrient management.

**Fig. 7.** Effect of wheat varieties and nutrient management systems on carbon footprint (pooled data of five years).

INM: Integrated nutrient management.

Table 7. Effect of wheat varieties and nutrient management systems on carbon budgeting (pooled data of five years)

Treatments	Carbon input (kg CO ₂ eq/ha)	Carbon output (kg CO ₂ eq/ha)	Net carbon gain (kg CO ₂ eq/ha)	Carbon efficiency	Carbon sustainability index	Carbon footprints (kg CO ₂ eq/kg)
JAUW-584	930	2363	1433	2.54	1.54	0.30
JAUW-672	932	2331	1399	2.50	1.50	0.28
DBW-222	928	2403	1475	2.59	1.59	0.25
HD-3237	931	2487	1556	2.67	1.67	0.24
INM	1140	2743	1603	2.41	1.41	0.29
Organic farming	1090	2396	1306	2.20	1.20	0.31
Natural farming	970	2049	1079	2.11	1.11	0.32

INM: Integrated nutrient management; common carbon input in transplanted rice: 928 kg CO₂ eq/ha.

Table 8. Effect of wheat varieties and nutrient management systems on relative economics (pooled data of five years)

Treatments	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	Benefit-cost ratio
JAUW-584	33363	74278	40915	1.23
JAUW-672	33575	76807	43232	1.29
DBW-222	33288	82467	49179	1.48
HD-3237	33888	86385	52497	1.55
INM	46050	121424	75374	1.64
Organic farming	51038	107248	56210	1.10
Natural farming	34925	91266	56341	1.61

The better crop performance was also reflected in the soil properties. The variety HD-3237 contributed greater root biomass and crop residues, resulting in an improved soil organic matter status. Among the nutrient management systems, organic farming recorded better soil health parameters owing to the continuous addition of organic manures, which enhanced soil organic carbon, microbial activity and nutrient cycling while reducing bulk density. Improved soil structure, aeration and moisture retention under organic farming further contributed to enhanced soil quality and long-term soil fertility. The continuous incorporation of organic materials also played an important role in improving carbon sequestration and sustaining soil productivity (21–25).

The higher biomass production and yield recorded in HD-3237 also contributed to superior energy and carbon-use performance. The variety exhibited higher energy productivity, energy-use efficiency, net energy, carbon output and net carbon gain owing to its greater ability to convert production inputs into economic yield and biomass. Among nutrient management systems, INM recorded higher energy input but also generated substantially higher output energy and carbon output due to increased productivity. In contrast, natural farming required minimal external inputs and therefore exhibited relatively higher energy-use efficiency despite lower overall productivity. Reduced biomass production under organic and natural farming systems resulted in comparatively lower carbon indices than under INM (26–29).

The superior growth, yield and resource-use efficiency of HD-3237 ultimately resulted in better economic returns. The higher grain and straw yields increased the gross and net returns without a proportionate increase in cultivation costs. Similarly, INM proved economically superior owing to balanced nutrient supply, enhanced nutrient-use efficiency and increased productivity. Although the cost of cultivation was slightly higher under INM, the additional expenditure was compensated for by higher yields, resulting in greater net returns and profitability. Therefore, the combination of HD-3237 and INM emerged as the most productive, resource-efficient and economically viable production system (30–33).

Conclusion

Based on findings of the study, it can be concluded that growing the wheat variety HD-3237 under integrated nutrient management resulted in higher grain yield, yield sustainability index, nutrient uptake, carbon sustainability index and benefit-cost ratio.

With regard to soil properties, cultivation of the wheat variety HD-3237 under organic farming resulted in higher soil organic matter, available soil nutrients, carbon sequestration and lower bulk density. However, in terms of energy indices, cultivation of the wheat variety HD-3237 under natural farming resulted in lower input energy, energy intensiveness, higher energy productivity and energy-use efficiency.

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Authors' contributions

RG conducted the research and prepared the initial draft of the manuscript. PC reviewed and corrected the manuscript. VT contributed to the manuscript revision and performed the modification and sequence alignment. PKS and PK were responsible for the preparation and arrangement of the tables. AS and PA assisted in reorganising the subheadings and finalising the manuscript. MS contributed to organising the subtopics. SS assisted in searching and compiling relevant literature and data. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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