



# Impact of Natural Farming Cropping System on Rural Households—Evidence From Solan District of Himachal Pradesh, India

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### Specialty section:

This article was submitted to  
Land, Livelihoods and Food Security,  
a section of the journal  
Frontiers in Sustainable Food Systems

Received: 17 February 2022

Accepted: 08 April 2022

Published: 31 May 2022

### Citation:

Laishram C, Vashishat RK, Sharma S,  
Rajkumari B, Mishra N, Barwal P,  
Vaidya MK, Sharma R, Chandel RS,  
Chandel A, Gupta RK and Sharma N  
(2022) Impact of Natural Farming  
Cropping System on Rural  
Households—Evidence From Solan  
District of Himachal Pradesh, India.  
*Front. Sustain. Food Syst.* 6:878015.  
doi: 10.3389/fsufs.2022.878015

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Natural farming, popularly known as zero budget natural farming, is an innovative farming approach. It is low input based, climate resilient, and low cost farming system because all the inputs (insect repellents, fungicides, and pesticides) are made up of natural herbs and locally available inputs, thereby reducing the use of artificial fertilizers and industrial pesticides. It is becoming increasingly popular among the smallholder farmers of Himachal Pradesh. Under the natural farming system, 3 to 12 crops are cultivated together on the same area, along with leguminous crops as intercrop in order to ensure that no piece of land is wasted and utilized properly. This article focuses mainly on the different cropping systems of natural farming and comparing the economics of natural farming (NF) with conventional farming (CF) systems. Study shows that farmers adopted five major crop combinations under natural farming system, i.e., vegetables-based cropping system (e.g., tomato + beans + cucumber and cauliflower + pea + radish), vegetables-cereals-based cropping system, and other three more cropping systems discussed in this article. The results indicated that a vegetable-based cropping system has 19.68% more net return in Kharif season and 24.64% more net return in Rabi season as compared to conventional farming vegetable-based monocropping system. NF maximizes land use and reduces the chance of crop yield loss. NF has resulted in increased returns especially in the vegetable cropping system where reduction in cost was 30.73 per cent (kharif) and 11.88 per cent (rabi) across all crop combinations in comparison to CF. It is found in study that NF was cost savings from not using chemical fertilizers and pesticides, as well as higher benefit from intercrops.

**Keywords:** natural farming, sustainability, crop combinations, intercropping, Himachal Pradesh

## INTRODUCTION

For around 58% of India's population, agriculture is their major source of income. Agriculture, forestry, and fishery had a gross value added of Rs 19.48 lac crore (US\$ 276.37 billion) in fiscal year 2020. In fiscal year (FY) 2020, agricultural and allied industries accounted for 17.8% of India's gross value added (GVA) at current prices. Consumer expenditure in India would increase by as much as 6.6% in 2021. India's share in world agricultural exports increased to 2.1% in 2019 from 1.71% in 2010 (Ministry of Commerce, 2021).

The country achieved its remarkable agricultural growth in the 1960s, after the emergence of the Green Revolution. India marked a new era in Indian agricultural history. The Green Revolution technology aimed to increase agricultural production mainly by substituting typically hardy plant varieties with high-response varieties and hybrids, the use of fertilizers and plant protection chemicals, irrigating more cultivated land by investing heavily on large irrigation systems, and consolidation of agricultural holdings (Sebby, 2010). India has gained its outstanding position in food production, but it is also facing a poor ranking in the hunger index (Menon et al., 2008). The Green Revolution left its harmful footprints on Indian agriculture. The monocropping system, increased and frequent use of fertilizers and pesticides caused considerable damage to the soil's biological operation, crop diversity, increased cost of cultivation, deterioration of groundwater, loss of flora-fauna, increased human diseases, malnutrition, and decreased soil fertility, which have almost left it barren in large areas. As a consequence, farmers with small farms invest in these costly inputs, which are exposed to high monetary risks and push them in the debt cycle (Eliazer et al., 2019). With pesticides' obvious environmental and ecological effects, it is no surprise that government laws have been strengthened (Carrington, 2019). Furthermore, the possible health implications of pesticide residue have terrified many of us into choosing pesticide-free items. Even though rules exist to assure legal maximum residual levels that have been considered scientifically acceptable for food, the campaign to eliminate pesticides has gained traction. Restoring soil health by reverting to non-chemical agriculture has assumed great importance in achieving sustainability in production.

In India, a chemical-free and climate-resilient method of farming given by a scientist Subhash Palekar, during 2006 in Maharashtra to end the problems arising after the Green Revolution by introducing natural farming. His methods popularized when farmers started adopting his methods. After that, many researchers and scientists claimed that natural farming is a good alternative to chemical farming that directly or indirectly impacts sustainable development positively (Tripathi and Tauseef, 2018). The aim of natural farming is to reduce the cost of production to almost zero and to come back to the "pre-Green Revolution" style of agriculture (Khadse et al., 2017). This would seem to lead growers out of loans by putting a stop to agricultural chemicals practices. The central government has implemented a policy to encourage farming methods throughout India. The state governments of Andhra Pradesh, Chhattisgarh, Himachal Pradesh, Uttarakhand, Kerala, and Karnataka asked

Subhash Palekar to educate their farmers for natural farming (Khadse and Rosset, 2019a,b).

In order to promote natural farming in Himachal Pradesh, a scheme "Prakritik Kheti Khushhal Kisan" was initiated with a budget allocation of Rs 35 crore (2019–2020). Under this scheme, peasants will be supported with training, the required machinery, to achieve the objective of sustainable farming doubling farmers' incomes, improved soil fertility, and low input costs (Vashishat et al., 2021). Though the search for a better alternative shall always remain, right now natural farming is a credible alternative itself (Mishra, 2018).

Natural farming is a special form of agriculture that does not require any financial expenditure to purchase the essential inputs such as seeds, fertilizers, and plant protection chemicals from the market. Natural farming, though in its preliminary stages, is showing increased positive results and is being adopted by farmers in good faith. It is even cited by farmers that labor and production costs have drastically reduced 14–45% (Chandel et al., 2021).

The cropping system of natural farming focuses mainly on traditional Indian practices based on agroecology; natural farming absolutely requires no monetary investment for purchase of key inputs at all (Palekar, 2005). Due to its simplicity, adaptiveness, and huge reduction in cost of cultivation to know the impact of the cropping system of natural farming on the small and marginal farmers, this study was conducted.

The objectives of this study will be:

- i) To study the socioeconomic status of the farmers.
- ii) To study the comparative economics of natural farming vis-à-vis conventional farming.
- iii) To identify the constraints of natural farming.

## METHODOLOGY

### Selection of the Study Area and Respondents

Solan district of Himachal Pradesh was purposely selected for this study. The district comprises five development blocks, i.e., Dharampur, Kandaghat, Nalagarh, Solan, and Kunihar. Out of these, three blocks were selected randomly and a list of farmers practicing both the Subhash Palekar Natural Farming (SPNF) and conventional farming were procured from the Project Director ATMA, Solan. From the list, 20 farmers each from the three selected blocks were selected randomly. Thus, total samples of 60 farmers were selected for this study. The primary data were collected from the farmers practicing both the natural farming and conventional farming systems by survey method using a well-structured and pre-tested schedule (questionnaire).

### Distribution of Sampled Farmers Practicing Natural Farming According to Their Size of Landholding

For the analysis of data, the total respondents were divided according to the size of their landholdings into three classes, viz., marginal (<1 ha), small (1–2 ha), and medium (2–4 ha). The distribution of the sampled farmers is given in **Table 1**.

**TABLE 1** | Distribution of sampled households according to their landholdings.

Sr. no.	Category of farmer	No. of farmers	Average size of land holding (ha)
1.	Marginal (< 1 ha)	33 (55)	0.51
2.	Small (1–2 ha)	17 (28.33)	1.09
3.	Medium (2–4 ha)	10 (16.67)	2.02
4.	Total	60 (100)	1.68

Figures in parentheses are percentage to the total.

## ANALYTICAL FRAMEWORK

To fulfill the above specified objectives of this study, based on the nature and extent of availability of data, the following analytical tools and techniques have been employed for the analysis of the data.

### Tabular Analysis

Simple tabular analysis was used to examine socioeconomic status, resource structure, income and expenditure pattern, and farmers' opinions about the production and marketing problems under natural farming. Simple statistical tools such as averages and percentages were used to compare, contrast, and interpret the results. The sex ratio, literacy rate, and index were calculated using the following formulae:

$$\text{Literacy rate} = \frac{\text{Total no. of literate person}}{\text{Total population}} \times 100$$

$$\text{Literacy Index} = \frac{\sum W_i X_i}{\sum X_i}$$

Where,

$W_i$  = Weights (0, 1, 2, 3, 4, and 5) for illiterate, primary, middle, metric, secondary, and graduate and above, respectively.

$X_i$  = Number of persons in respective category.

$$\begin{aligned} \text{Dependency ratio w.r.t. total workers} \\ &= \frac{\text{No. of dependents in a family}}{\text{Total workers}} \end{aligned}$$

$$\begin{aligned} \text{Dependency ratio w.r.t. average size of family} \\ &= \frac{\text{No. of dependents in a family}}{\text{Family Size}} \end{aligned}$$

$$\begin{aligned} \text{Cropping intensity} \\ &= \frac{\text{Gross cropped area}}{\text{Net sown area}} \times 100 \end{aligned}$$

## Costs and Returns Analysis

### Commission for Agricultural Costs and Prices Cost Concepts

Cost  $A_1$  includes:

- i) Cost of planting material cost
- ii) Cost of manures, fertilizers, and plant protections

- iii) Cost of hired human labor
- iv) Cost of owned and hired machinery
- v) Irrigation charges
- vi) Depreciation on implements, farm buildings, and irrigation structures
- vii) Land revenue
- viii) Interest on owned working capital
- ix) Other miscellaneous charges.

- **Cost  $A_2$ :** Cost  $A_1$  + rent paid for leased-in land
- **Cost  $B_1$ :** Cost  $A_1$  + interest on the fixed capital assets excluding land
- **Cost  $B_2$ :** Cost  $B_1$  + rental value of owned land
- **Cost  $C_1$ :** Cost  $B_1$  + imputed value of family labor
- **Cost  $C_2$ :** Cost  $B_2$  + imputed value of family labor
- **Cost  $C_3$ :** Cost  $C_2$  + 10% of cost  $C_2$  on account of managerial function performed by the farmer.

### Crop Equivalent Yield

In natural farming system, many types of crops were cultivated in a multiple or mixed cropping. So, it was very difficult to compare the economics of multiple crops with a single crop. Francis (1986) described crop equivalent yield (CEY) to the sum of equivalent principal and intercrop yields. The differing yield intercrops were transformed into the equivalent yield of any crop depending on the commodity price. So, a comparison was made based on economic returns and crop equivalent yield (CEY) of multiple cropping sequences was calculated by converting the yield of different intercrops/crops into equivalent yield of any one crop based on price of the produce. Mathematically, the CEY is represented as:

$$\text{CEY} = C_Y + C_{Y1} \frac{P_1}{P_0} + C_{Y2} \frac{P_2}{P_0} \dots$$

Where,

$C_Y$  = Yields of the main crop

$P_0$  = Price of the main crop

$(C_{Y1}, C_{Y2}, C_{Y3} \dots C_{Yn})$  = Yields of intercrop, which are to be converted to equivalent of main crop yield

$(P_1, P_2, P_3 \dots P_n)$  = Price of the respective intercrops.

### Relative Economic Efficiency

Farrell (1957) distinguished three types of efficiency, namely, technical efficiency, price or allocative efficiency, and economic efficiency (which is a combination of the first two). Economic efficiency is distinct from the other two efficiencies, even though it is the product of technical and allocative efficiencies. Relative economic efficiency, which is a comparative measure of economic gains, can be calculated by:

$$\text{REE} = \frac{\text{Net Returns in Natural Farming} - \text{Net Returns in Conventional Farming}}{\text{Net Returns in Conventional Farming}} \times 100$$

### Statistical Analysis

The comparative economics was statistically analyzed as per the procedure given by Gomez and Gomez (1984). The ANOVA was carried out based on the model in **Table 2**.

**TABLE 2** | ANOVA (two-rowed without replication) layout.

Source of variation	SS	df	MS	F	P-value (at 0.05)	F crit
<b>ANOVA</b>						
Rows	SSr	r-1	MSr = SSr/(r-1)	MSr/MSe	—	—
Columns	SSc	c-1	MSc = SSc/(c-1)	MSc/MSe	—	—
Error	SSe	(r-1)(c-1)	MSe = SSe/(r-1)(c-1)			
Total	SSt	rc-1				

r, No. of rows; c, No. of columns.

## Production and Marketing Problems

To study the various problems associated with the production and marketing of natural farming, it was assumed that the extent of a particular problem varies from place to place and farmer to farmer. The multiple responses of producers reporting various problems were taken into consideration for analysis.

### Garrett's Ranking Technique

The Garrett's ranking technique (Garrett and Woodworth, 1969) was used for examination of constraints. It is important to note here that these constraints were focused on the response of all the sample farmers. The respondents were asked to rank the problems in turmeric and cotton production, processing, and marketing. In the Garrett's ranking technique, these ranks were converted into percent position by using the formula:

$$\text{Percent position} = \frac{100(R_{ij} - 0.5)}{N_j}$$

Where,

$R_{ij}$  = Ranking given to the  $i$ th attribute by the  $j$ th individual

$N_j$  = Number of attributes ranked by the  $j$ th individual.

By referring to the Garrett's table, the percentage positions estimated were converted into scores. Thus, for each factor, the scores of the various respondents were added and the mean values were estimated. The mean values, thus, obtained for each of the attributes were arranged in descending order. The attributes with the highest mean value were considered as the most important one and the others followed in that order.

### Chi-Squared Test

To test whether there was any significant difference among marginal, small and medium farms of Solan for the problems faced by them, chi-square test (Pearson, 1900) in  $(m \times n)$  contingency table was applied where  $m$  and  $n$  are the number of marketing problems faced by the farmers of natural farming in Solan district. The detail of approximate chi-squared test is given as under:

$$\sum_{j=1}^L \sum_{i=1}^K \frac{(O_i - E_i)^2}{E_i} \sim \chi^2 (L - 1)(K (L1)) \text{ d.f.}$$

Where,

O = Observed values

E = Expected values

K = Number of problems

L = Number of the farm size groups.

## RESULTS AND DISCUSSION: SOCIO-ECONOMIC CHARACTERISTICS OF SAMPLED HOUSEHOLDS

### Size and Structure of the Sampled Households in the Study Area

The size and structure of the family play an important part in influencing crop production. The size and structure of the sampled households in the study area are given in **Table 3**. At an overall level, the average family size was 5.28 out of which 51.64% were males, 39.66% were females, and 8.70% were children. The average family size ranged from 5.21 to 5.35 and was observed highest in the small farmers (5.35) followed by medium farmers (5.30) and marginal farmers (5.21). The results indicated that the dominant family structure in the area under study was the nuclear family (66.67%). It was highest in small farms (47.06%) followed by marginal (30.30%) and medium farm categories (20%).

### Literacy Status of the Sampled Households

Literacy is an indicator of an individual's educational status and level of education enabling him/her to engage and participate in enhancing and improving the social and economic well-being of the surroundings. Good literacy skills open up doors for education and jobs, so people can avoid poverty and underemployment. The rate of literacy is a reflection of good human capital. Higher literacy leads to a higher level of awareness, interaction with new inventions and technologies, etc. The literacy status of the sampled households is given in **Table 4**. It is revealed from **Table 4** that the overall literacy rate was 89.70% in males and 77.52% in females and the highest literacy rate was observed in the small farm category with 91.30% in males and 78.05% in females. **Table 4** shows that 23.55% males and 7.35% females had education level upto graduation and above. The literacy index varied from 1.58 to 2.30 in males among different farm categories, while the literacy index varied from 1.73 to 2.26 in females among different farm categories, which clearly show the poor quality of education. As the level of education increases, nowadays people understand the importance of better healthcare and due to that many farmers have started to focus

**TABLE 3** | Demographic profile of sampled households in the study area (No.).

Particulars	Farm category			
	Marginal	Small	Medium	Overall
<b>Family structure</b>				
1. Joint family	10.00 (30.30)	8.00 (47.06)	2.00 (20.00)	20.00 (33.33)
2. Nuclear family	23.00 (69.70)	9.00 (52.94)	8.00 (80.00)	40.00 (66.67)
3. Total	33.00 (100.00)	17.00 (100.00)	10.00 (100.00)	60.00 (100.00)
<b>Family size</b>				
1) Male	2.66 (51.16)	2.70 (50.55)	2.90 (54.72)	2.72 (51.64)
2) Female	2.06 (39.54)	2.23 (41.76)	1.90 (35.85)	2.09 (39.66)
3) Children	0.48 (9.30)	0.41 (7.69)	0.50 (9.43)	0.45 (8.70)
Average family size	5.21 (100.00)	5.35 (100.00)	5.30 (100.00)	5.28 (100.00)

Figures in parentheses are percentage to average family size.

**TABLE 4** | Farm category-wise literacy status of sampled households (%).

Particulars	Farm categories							
	Marginal		Small		Medium		Overall	
	Male	Female	Male	Female	Male	Female	Male	Female
Illiterate	11.11	21.62	8.70	20.93	9.68	21.05	10.18	21.32
Primary	5.56	10.8	2.17	20.93	32.26	0	9.58	12.50
Middle	21.11	17.57	21.74	11.63	12.90	21.05	19.76	16.18
High school	15.56	25.68	26.09	18.60	12.90	15.79	17.96	22.06
Sr.Sec	18.89	12.16	21.74	13.95	9.68	31.58	17.96	15.44
Graduation	25.55	5.41	19.57	9.30	22.58	10.53	23.35	7.35
Non-school going (below 5 yrs)	2.22	6.75	0	4.65	0	0	1.19	5.14
Total	100	100	100	100	100	100	100	100
Literacy rate	88.64	76.81	91.30	78.05	90.32	78.95	89.70	77.52
Literacy index	2.00	1.90	2.30	1.73	1.58	2.26	2.00	1.90

more on natural farming and have no adverse impact on human health.

## Occupational Distribution of the Sampled Households

The occupational patterns play a very significant role in ascertaining the economic status of the family. In this way, we know about the households engaged in various activities such as agriculture, business, and government or private services. In developing countries, the majority of the population are still engaged in agricultural activities and other primary activities. When the area is more developed, the employment patterns will be more diversified and household incomes will also increase. Development and progress of employment are very much linked to economic development. The occupational structure, allocation of workers, and number of dependents are shown in **Table 5**.

The workforce reflects the distribution of members of the household making a contribution to the household economy. A family with more working people will be much more precise in terms of their livelihood strategies. **Table 5** concludes that 81.33% of the households are engaged in agriculture, which means that

agriculture being the main occupation in the study area. With the growing importance of natural farming, farmers have become more aware of the importance of health benefits and, hence, the percentage of farmers engaged in this sector is coming out highest as compared to business and services. On an average, 2.90 per worker were engaged in business and public/private sector (15.77%), respectively.

The largest proportion of productive agricultural workers was observed in the medium farm category with 83.33% followed by the marginal (81.75%) and small farm categories (70.10%). So, as far as the average number of dependents is concerned, the highest percentage was observed in the marginal farm (26.74%) followed by the small farm (26.37%) and lowest in the medium farm category (24.53%). At the overall level, productive workers were 3.88 and varied from 3.82 to 4.00 in the marginal to medium farm categories. The overall dependency ratio with respect to workers was (1:0.35) and among the different categories, the highest was observed in marginal category (1:0.37), followed by small (1:0.36) and medium farm categories (1:0.33). Dependency result illustrates that on average, one worker has to support less than one member of the family in the sampled household.



**TABLE 5** | Farm category-wise occupational distribution of the sampled households (No.).

Sr. no.	Particulars	Farm categories			
		Marginal	Small	Medium	Overall
I	Agriculture	3.12 (81.75)	3.12 (79.10)	4.00 (83.33)	3.27 (81.33)
II	Business	0.09 (2.38)	0.24 (5.97)	0.00 (0.00)	0.12 (2.90)
III	Services	0.61 (15.87)	0.59 (14.93)	0.80 (16.67)	0.63 (15.77)
	Average no. of workers	3.82 (73.26)	3.94 (73.63)	4 (75.47)	3.88 (62.44)
	Average no. of dependents	1.39 (26.74)	1.41 (26.37)	1.30 (24.53)	1.40 (37.56)
	Average family size	5.21 (100)	5.35 (100)	5.30 (100)	5.28 (100)
	Dependency ratio w.r.t workers	0.37	0.36	0.33	0.35
	Dependency ratio w.r.t family size	0.27	0.26	0.25	0.26

Figures in parentheses are percentage to average number of workers.

**TABLE 6** | Gender-wise distribution of the farm workers in the sampled households (No.).

Particulars	Marginal	Small	Medium	Overall
Male	1.67 (52.94)	1.59 (49.09)	2.50 (62.50)	1.79 (53.81)
Female	1.45 (47.06)	1.53 (50.91)	1.50 (37.50)	1.48 (46.19)
Average no. of farm workers	3.12 (100)	3.12 (100)	4.00 (100)	3.27 (100)

Figures in parentheses are percentages to the total.

**Table 6** reveals that the majority of the workforce were the males (53.81 %), while the female workers constituted 46.19%. The percentage of the male workers was the highest in medium farm category (62.50%) followed by marginal (52.94%) and small farm categories (49.09%). The proportion of female workers was considered to be the highest (50.91%) in the small farm category followed closely by the marginal (47.06%) and medium-farm categories (37.50%).

## Season-Wise Major Crop Combinations Under Natural Farming System

Under natural farming system, three to four crops are cultivated or grown together on the same area, along with leguminous crops as intercrop in order to ensure that no piece of land is wasted and utilized properly. These combinations during the growing season were established to encourage interaction between them and are based on the idea that complementarities exist between the plants. Intercropping with leguminous crops is considered as one of the most important components of natural farming as it increases crop productivity and soil fertility through the atmospheric nitrogen fixation. These complementarities between crops increase soil and its nutrients. It also involves diversification and improves profits by growing and selling various types of cereals, vegetables, legumes, fruit, and even medicinal plants. The multiple cropping systems substantially enhance income. This system maximizes land use and reduces the chance of crop yield loss. This study found that farmers grow different crops under different crop combinations in the study area. The major crop combinations adopted by the selected farmers were categorized as: (i) vegetables, (ii) vegetables-cereals,

(iii) vegetables-pulses, (iv) cereals-pulses, and (v) vegetables-oilseeds crops. From **Table 7**, it was observed that in Kharif season, the major vegetable being grown in the study area was tomato and the other crops included were capsicum, cucumber, bottle gourd, chili, okra, brinjal, etc. The main intercrops (leguminous) in the study area include French bean and soybean. The major cereals and pulses include maize, beans, soybean, etc. While in Rabi season, cauliflower is the major vegetable followed by wheat, pea, and chickpea as the major cereals and pulses grown in the study area. The other crop includes radish, fenugreek, coriander, spinach, potato, onion, garlic, etc. Mustard was being grouped under as major oilseeds crops. The main leguminous crops (intercrops) in Rabi season were pea, chickpea, and kidney beans.

Now, in conventional farming, as opposed to natural farming, solo cropping is practiced. From **Table 8**, it was observed that the main crops grown by the farmers were tomato and maize in the Kharif season and in Rabi season, the main crops grown were cauliflower, wheat, chickpea, and mustard.

So, in order to compare within these two systems, one main crop is kept common between the two systems. For example, from **Table 1**, in the Kharif season, in natural farming, in vegetables crop combination, it was observed that tomato is the main crop and it was being planted along with several crops. Similarly, in **Table 8**, under conventional farming, it was seen under the vegetables section (Kharif season) that the main crop is tomato. So, in order to compare these two systems, a comparison was made based on economic returns and, henceforth, crop equivalent yield (CEY) of multiple cropping sequences was calculated by converting the differing yields of intercrops into the equivalent yield of the main crop, i.e., tomato (in case of

**TABLE 7** | Season-wise major crop combinations under natural farming (NF) system.

Particulars	Kharif	Rabi
Vegetables	Tomato + Beans + Cucumber	Cauliflower + Pea + Radish
	Tomato + Beans	Cauliflower + Pea + Fenugreek
	Tomato + Beans + Capsicum	Cauliflower + Pea + Coriander
	Tomato + Beans + Chili	Cauliflower + Pea + Spinach
	Tomato + Beans + Bottle Gourd	Cauliflower + Pea + Potato
	Tomato + Bean + Okra	Cauliflower + Pea + Onion
	Tomato + Beans + Brinjal	Onion + Pea + Fenugreek
	Capsicum + Beans	Cauliflower + Pea Cabbage + Pea + Fenugreek
Vegetables-Cereals	Tomato + Maize + Beans	Potato + Wheat + Pea
	Capsicum + Maize + Beans	Cauliflower + Wheat + Pea
	Bottle Gourd + Maize + Beans	Colocasia + Wheat + Pea
	Tomato + Maize + Beans	
Vegetables-Pulses	Tomato + Soyabean	Cauliflower-Chickpea
	Tomato + Soyabean + Cucumber	Cauliflower + Kidney Beans + Potato
	Tomato + Soyabean + Chili	Cauliflower + Chickpea + Coriander
Cereals-Pulses	Okra + Beans	Cauliflower + Chickpea + Fenugreek
	Maize + Soyabean	Wheat + Chickpea Wheat + Chickpea + Mustard Wheat + Chickpea + Pea
		Cauliflower + Mustard + Fenugreek
Vegetables-Oil seeds	--	Cauliflower + Mustard + Cabbage
	--	Cauliflower + Mustard + Coriander
	--	Cauliflower + Mustard + Radish
	--	Cauliflower + Mustard
	--	

vegetables crop combination for both the systems) depending on price of the produce. Similarly, CEY of other crop combinations was also calculated by using this same method mentioned above.

## Comparative Analysis of Natural Farming System and Conventional Farming System Yield

Under natural farming system, two or three crops are cultivated on the same farmland. Because different crop types were grown in a multiple or mixed crop system, it was hard to equate NFs economic produce with CF. So, to compare the yield, the crop equivalent yield (CEY) concept was used for a mixed cropping

**TABLE 8** | Season-wise major crop combinations under conventional farming (CF) system.

Particulars	Kharif	Rabi
Vegetables	Tomato	Cauliflower
Vegetables-Cereals	Maize	Wheat
Vegetables-Pulses	Tomato	Chickpea
Cereals-Pulses	Maize	Wheat
Vegetables-Oil seeds	--	Mustard

system. In the statistical analysis shown in **Tables 9, 10**, we can observe that, along the rows, all the crop combinations have significantly higher yields under NF as compared to CF in both the seasons. Now, from **Table 11**, it was observed that, for all the crop combinations, the yield in the NF system was found to be higher than the CF system and it varied from 49.20 to 208.45 q/ha. The maximum yield was observed in vegetables 208.45 q/ha for the Kharif season. In the case of the Rabi season, it ranged from 48.33 to 58.12 q/ha. Same results were found like Kharif season, i.e., yield in all the crop combinations under NF was more than of CF. The maximum yield was observed in vegetables crop combination (58.12 q/ha). From **Table 11**, it was observed that CEY of the NF system was found to be greater than that of those of the CF system. All the NF crop combinations show an average increase in yield over the CF system. In the Kharif season, the increase in the yield under NF system over CF system varied from 3.08 to 5.10%, while in Rabi season, it ranged from 2.83 to 7.98% in all the crop combinations. In Kharif season, the maximum increase in yield under NF was observed in vegetables and cereals-pulses in Rabi season. The above results were supported by Tripathi and Tauseef (2018), which stated that the average of zero budget natural farming (ZBNF) groundnut farmers was 23% higher than their counterparts outside the ZBNF. On average ZBNF, paddy farmers had a 6% higher yield. These increments are the result of sustainable farming practices, which also improve farmers' capacity to adapt to climate change. Also, another study observed an increase in CEY under cereals-pulses combination (17.22%). This higher increase can be attributed to the comparative remunerative prices of pulses and symbiotic effect of pulses on cereal crop yield (Chandel et al., 2021).

## Cost of Cultivation

One of the key cost components for the production of cash crops such as fruits and vegetables under the CF system in the state is chemical inputs. This continuous farming activity has contributed to higher costs and eventually reduced incomes for farmers. A substantial decrease in the cost of growing these crops has occurred with the use of NF technology. **Tables 12, 13** indicate the statistical analysis of the cost of cultivation where we can observe that, along the rows, all the crop combinations have significantly lower costs under NF as compared to CF in both the seasons. **Table 14** presents a comparison of cost of cultivation between NF and CF systems. It has been observed that the total cost of all the crop combinations in NF systems during the cultivation process was substantially reduced. In the

**TABLE 9** | Statistical analysis of Kharif season from **Table 11**.

Source of variation	SS	df	MS	F	P-value	F crit
<b>ANOVA</b>						
Rows	25863.47	3	8621.156	1487.18	2.96E-05	9.276628
Columns	58.42805	1	58.42805	10.07904	0.050297	10.12796
Error	17.39095	3	5.796983			
Total	25939.29	7				

**TABLE 10** | Statistical analysis of Rabi season from **Table 11**.

Source of variation	SS	df	MS	F	P-value	F crit
<b>ANOVA</b>						
Rows	154.32116	4	38.58029	66.61422	0.00065	6.388233
Columns	14.78656	1	14.78656	25.53104	0.007217	7.708647
Error	2.31664	4	0.57916			
Total	171.42436	9				

**TABLE 11** | Crop equivalent yield (CEY) of various crop combinations under NF and conventional farming (CF) systems.

Crops combination	CEY (q/ha)					
	Kharif			Rabi		
	NF	CF	% increase in NF over CF	NF	CF	% increase in NF over CF
Vegetables	208.45	198.34	5.10	60.75	58.12	4.53
Vegetables+Cereals	160.5	155.59	3.16	53.19	51.3	3.68
Vegetables+Pulses	155.13	150.5	3.08	59.79	57.7	3.62
Cereals+Pulses	49.2	47.23	4.17	56.54	52.36	7.98
Vegetables+Oilseeds	-	-	-	49.7	48.33	2.83

**TABLE 12** | Statistical analysis of Kharif season from **Table 14**.

Source of variation	SS	df	MS	F	P-value	F crit
<b>ANOVA</b>						
Rows	13527216	3	4509072	62.84556	0.003312	9.276628
Columns	1.29E+08	1	1.29E+08	1793.277	2.9E-05	10.12796
Error	215245.4	3	71748.46			
Total	1.42E+08	7				

**TABLE 13** | Statistical analysis of Rabi season from **Table 14**.

Source of variation	SS	df	MS	F	P-value	F crit
<b>ANOVA</b>						
Rows	4.3E+08	4	1.08E+08	159.4464	0.000116	6.388233
Columns	78596123	1	78596123	116.5028	0.000418	7.708647
Error	2698515	4	674628.8			
Total	5.12E+08	9				

Kharif season, the percentage reduction in NF cultivation costs over the CF system ranged from 12.56 to 30.73%, while in the Rabi season it ranged from 6.86 to 12.34%. In Kharif season,

maximum reduction in cost was observed in vegetables crop combination, whereas in case of Rabi season, the maximum reduction was observed in cereal-pulses crop combination. This



**TABLE 14** | Cost of cultivation of various crop combinations under NF and CF systems.

Crops combination	Cost of cultivation (Rs/ha)					
	Kharif			Rabi		
	Total cost		% change in NF over CF	Total cost		% change in NF over CF
NF	CF	NF		CF		
Vegetables	55,056	79,485	-30.73	55,511	62,992	-11.88
Vegetables+Cereals	55,302	70,117	-21.13	59,288	63,652	-6.86
Vegetables+Pulses	54,478	72,304	-24.65	57,354	62,754	-8.60
Cereals+Pulses	52,359	59,880	-12.56	40,605	46,322	-12.34
Vegetables+Oilseeds	-	-	-	52,374	57,447	-8.83

**TABLE 15** | Statistical analysis of Kharif season from Table 17.

Source of variation	SS	df	MS	F	P-value	F crit
<b>ANOVA</b>						
Rows	8.04E + 1 0	3	2.68E + 10	707.1091	9.01E-05	9.276628
Columns	2.39E + 08	1	2.39E + 08	6.321019	0.08662	10.12796
Error	1.14E + 08	3	37887489			
Total	8.07E + 10	7				

**TABLE 16** | Statistical analysis of Rabi season from Table 17.

Source of variation	SS	df	MS	F	P-value	F crit
<b>ANOVA (Rabi)</b>						
Rows	1.6E+09	4	4.01E+08	584.8605	8.73E-06	6.388233
Columns	7250523	1	7250523	10.57951	0.031298	7.708647
Error	2741345	4	685336.3			
Total	1.61E+09	9				

indicates that the NF method lowers the costs of farmers as it uses non-synthetic inputs locally in contrast to CF capital intensive inputs. Similar findings have been published, which revealed that, after converting into ZBNF, farmers had a decreased cost of cultivation for all the crops and, most significantly, farmers were able to increase their income from natural agricultural practices by increasing the number of crops (Mishra, 2018). In another study, it was observed that the total cost of cultivation was reduced across all the crop combinations. The total expenditure in fruit-based cropping sequences showed a marked decline from Rs. 2,40,638 to Rs. 1,31,023 per ha., which indicate that the SPNF system reduces farmers' direct costs, boosting yields, and promotes the use of locally sourced non-synthetic inputs, compared to capital intensive CF (Chandel et al., 2021).

Conventional farming currently faces numerous challenges such as decreasing factor productivity, inappropriate and imbalanced use of nutrients, poor water and nutrient quality, depletion of natural resources, and increased input costs. Different crop combinations have clearly demonstrated that chemical-based farming technologies are highly capital intensive.

## Net Returns

The profits and losses of a farm are reflected through its net income. It constitutes gross returns from the business after deduction of total cost incurred. In NF, input costs are highly diminished due to the abstinence from pesticides, insecticides, and adoption of natural inputs such as *jivamrit*, *bijamrit*, *ghanjivamrit*, and *neemastra*. NF inputs and other natural preparations have a major impact due to reduced expenditure on chemical fertilizers and pesticides. The statistical analysis for net returns under NF and CF is shown in Tables 15, 16. Here, it is very apparent that, along the rows, all the crop combinations have significantly higher net returns under NF as compared to CF in both the seasons. Furthermore, Table 17 reveals that net returns in NF were higher than CF across all the crop combinations. The relative economic efficiency (REE), the comparative measure of economic gain in NF over the CF in all the crop combinations in the Kharif season, was 13.20 to 23.05% higher, while in the Rabi season, it was 24.16 to 31.30% higher in all the crop combinations. Maximum relative economic efficiency was observed in the cereals-pulses crop combination in the Kharif season and in Rabi season, the maximum relative economic efficiency was

**TABLE 17** | Crop combination-wise net returns under NF and CF systems.

Crops combination	Net returns (Rs/ha)					
	Kharif			Rabi		
	Net returns		Relative economic efficiency (%)	Net returns		Relative Economic Efficiency (%)
	NF	CF		NF	CF	
Vegetables	272,875	228,009	19.68	54,895	44,038	24.65
Vegetables + Cereals	245,648	215,284	14.10	34,007	27,390	24.16
Vegetables + Pulses	210,940	186,346	13.20	29,393	22,386	31.30
Cereals + Pulses	12,178	9,897	23.05	30,843	24,252	27.18
Vegetables + Oilseeds	—	—	—	27,886	22,409	24.44

**TABLE 18** | Farm category-wise problem faced by natural farming producer in study area (Multiple response, %).

Sr. no.	Problems	Marginal	Small	Medium	Overall	Chi square
1.	No. of farmers	33	17	10	60	60
a)	Skilled labor					
b)	Shortage of skilled labor	34.15	63.64	50.00	45.14	8.84
c)	Higher wages rates	17.07	27.27	37.50	23.37	7.65
d)	Non-availability at peak operation time	4.88	18.18	25.00	12.00	13.07
2.	Natural fertilizer					
a)	High preparing cost	31.71	27.27	50.00	33.50	7.99
b)	Inadequate training facilities	24.39	18.18	37.00	24.82	7.29
c)	Lack of extension facilities	19.51	36.36	25.00	25.20	5.48
d)	Inputs not available in time	17.07	18.18	12.50	16.63	1.14
3.	Lack of knowledge of package of practices	19.51	45.45	37.50	29.86	10.34
4.	Irrigation facility not available	7.32	18.18	12.50	11.26	4.66
5.	Non-availability of buyers	12.20	27.27	25.00	18.60	6.15
6.	Higher commission	7.32	18.18	25.00	13.34	9.45
7.	Wholesalers not taking consent while selling	4.88	9.09	0.00	5.26	8.89
8.	Delay in payments	12.12	17.65	20.00	15.00	1.97
9.	Non-availability of specialized market	65.85	63.64	62.50	86.37	14.91
10.	Lack of transport facilities	12.20	27.27	12.50	16.52	8.58
11.	Fair price for produce in market	70.73	118.18	87.50	86.97	12.57
12.	Lack of information	12.12	17.65	20.00	15.00	1.98

observed in the vegetables-pulses crop combination. Increased NF returns can be attributed to expenditure savings due to local inputs and additional revenue from intercrops. Mixed cropping helped to make more efficient use of the farm area than solo crop cultivation to further increase the net profit, in addition to increasing the variety of available crops at different times during the growing season. The results were supported by the same study undertaken by Chandel et al. (2021) which stated that the REE was 11.80 to 21.55% higher in all the crop combination under the SPNF as compared to the CF system.

## Problems Faced by the Natural Farmers

There are constraints when it comes to any development process. Likewise, there are several constraints regarding natural farming,

which were faced by the concerned natural farmers of Solan district. Some of the main constraints include unfair price in the market, irrigation facilities, lack of specialized markets for the produce, high wage rates, lack of training facilities, etc. For examination of constraints, the Garrett's ranking technique was used. It must also be noted that these limitations have been aimed at the response of all the sample farmers. **Table 18** shows the constraints faced by various farm categories.

## Chi-Squared Test

An effort was made to examine the problems between different farm categories in the field of production and marketing. The chi-squared tests have been performed to check if the problems are specified by farm category or are independent of the farm

**TABLE 19** | Farmers' perceptions and problems faced by NF growers in the study area.

Sr. no.	Factors	Garret score	Percent	Rank
1	Labor intensive farming	3,714	37.14	I
2	Higher wage rate	3,624	36.24	II
3	Non-availability of specialized market	3,552	35.52	III
4	Shortage of skilled labor	3,275	32.75	IV
5	Lack of knowledge for package of practices	3,244	32.44	V
6	Consumer awareness about NF produce	3,087	30.87	VI
7	Lack of extension facilities	2,995	29.95	VII
8	Unfair price for produce in the market	2,861	28.61	VIII
9	Lack of transport facilities	2,823	28.23	IX
10	Lack of Irrigation facility	2,775	27.75	X
11	Inadequate training facilities	2,737	27.37	XI
12	Lack of market information	2,583	25.83	XII
13	Wholesalers not taking consent while selling	2,585	25.85	XIII
14	Higher commission	2,531	25.31	XIV

category. As prices differ greatly, producers have had problems with production and marketing due to high wage levels, lack of technical awareness, lack of safe plant material, and lack of irrigation and storage facilities. These concerns were categorized in two subgroups: production issues and marketing issues.

It was observed from **Table 18** that among the production problems, shortage of skilled labor, higher wage rate, non-availability at peak operation time, and inadequate training facilities were found statistically significant. It showed significant differences between the different farm categories. In case of marketing problems, non-availability of specialized markets, lack of transport facility, and fair price in the market were found statistically significant. It showed that these problems were faced by all the farm categories.

### Garrett's Ranking Technique

The various problems faced by the farmers are shown in **Table 19**.

The Garrett's ranking system was used in this analysis, using the ranks attained by each problem to assess the most serious and the least serious problems. The major problems faced by the farmers were labor intensive (I) followed by higher wage rate (II), non-availability of specialized market (III), shortage of skilled labor (IV), knowledge of package of practices (V), consumer awareness about NF produce (VI), lack of extension facilities (VII), unfair price for produce in the market (VIII), etc. Other common problems include lack of transport facilities, lack of irrigation facilities, etc.

## CONCLUSION

Intercropping with leguminous crops is considered as one of the most important components of natural farming as it increases crop productivity and soil fertility through the atmospheric nitrogen fixation. The results revealed that farmers witnessed a drop in per hectare cost of production and profitable yield for their crops as well. The farmers were pleased that natural farming is both environmentally friendly and extremely cost-effective.

The crop equivalent yield (CEY) under natural farming was highest in all the crop combinations as compared to conventional farming and ranged from 3.08 to 5.10% in Kharif season and 2.83 to 7.98% in all the crop combinations in Rabi season. In Kharif season, the percentage reduction in cost of cultivation under NF over the CF system ranged from 12.56 to 30.73, while in Rabi season, it ranged from 6.86 to 12.34. The gross returns under NF systems were highest in all the crop combinations as compared to CF systems. The maximum increase in gross returns was in vegetables crop combination in both the seasons. The relative economic efficiency (REE) was highest in all the crop combinations under NF over CF system. Among the problems studied, shortage of skilled labor, higher wage rate, non-availability at peak operation time, inadequate training facilities, non-availability of specialized markets, lack of transport facility, and fair price in the market were found statistically significant. It showed significant differences between the different farm categories. The analysis showed that the natural farming system provides relatively higher returns per hectare than the conventional farming system. Also, it was observed that the major problems faced by the farmers were labor intensive (I) followed by higher wage rate (II), non-availability of specialized market (III), shortage of skilled labor (IV), knowledge of package of practices (V), consumer awareness about NF produce (VI), lack of extension facilities (VII), unfair price for produce in the market (VIII), etc. Other common problems include lack of transport facilities, lack of irrigation facilities, etc. So, there is a need for the Department of Agriculture to take up effective measures to encourage natural farming through campaigns by educating the farmers about its importance. The government should also encourage higher premium prices and channels of green marketing for the boosting of natural crops. The farmers should focus more on the full application of the NF model on their farm fields and should know the best way to use these products, i.e., proper mulching techniques (acchadan), application of *jivamrit*, *ghanjivamrit*, *bijamrit*, *astras*, etc., in order to enhance productivity.

## DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

## AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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