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Pattern of crop diversification in natural farming demonstration in Uttar Pradesh

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ABSTRACT

Natural Farming (NF) is increasingly promoted as an agroecological approach emphasizing reduced dependence on external inputs, ecological processes and diversified cropping systems. This study assessed the pattern and extent of crop diversification under NF demonstrations implemented through Krishi Vigyan Kendras (KVKs) in Uttar Pradesh during 2025–26. Data from 60 KVKs, 541 demonstrations and 234 participating farmers covering Kharif, Rabi and Summer seasons were analyzed at demonstration, farmer and KVK levels. Crop richness, mean crops per demonstration, Shannon diversity, Simpson diversity and Pielou's evenness were used to characterize diversification. The results showed that 37 distinct crops belonging to 11 crop groups were represented across the programme. However, diversification was expressed predominantly across farmers, KVKs and seasons rather than within individual demonstrations. The mean number of crops per demonstration was 1.12, with 93.2% of demonstrations being single-crop demonstrations. Kharif recorded the highest Shannon diversity ($H' = 1.801$; 22 crops), whereas Rabi had the lowest ($H' = 1.293$), largely due to wheat dominance (68.9% of crops cultivated). At the farmer level, the mean number of distinct crops was 1.92, with 79.9% of farmers classified as having low diversification. Repeated seasonal participation was associated with greater diversification, with mean distinct crops increasing from 1.02 among one-season participants to 3.51 among three-season participants. Considerable KVK-level variation was also observed. The findings highlight the potential of NF demonstrations to promote seasonal, farmer-level and location-specific crop diversification, particularly through pulses and green manure, while indicating scope for strengthening within-farm diversification through locally suitable crops and multi-season planning.

Keywords: Natural Farming, Crop diversification, Uttar Pradesh, Krishi Vigyan Kendras, Agroecological approach

Introduction

Indian agriculture is gradually transitioning to production systems that are environmentally sustainable, economically viable, and resilient to climatic and resource constraints. Rising costs of external agricultural inputs, concerns about soil health, declining ecological functions, and the need for safe, sustainable food production have increased the relevance of agro-ecological approaches such as natural farming. In this context, Natural Farming (NF) has emerged as a knowledge-intensive approach that seeks to reduce dependence on externally purchased chemical inputs while promoting ecological processes, diversified cropping systems and integration of livestock within farming systems. The approach draws upon traditional Indian knowledge while increasingly incorporating scientific research and validation through agricultural research institutions and universities. Recognising natural farming's potential to improve soil health, reduce production costs, and strengthen climate resilience, the Government of India approved the National Mission on Natural Farming (NMNF) on 25 November 2024 [1] as a Centrally Sponsored Scheme under the Department of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare. The mission seeks to facilitate a broader transition towards chemical-free farming through farmer awareness, capacity building, continuous hand-holding, decentralised learning systems and improved access to biological inputs. It also emphasises integrating livestock, diversified cropping, and locally available resources as key components of natural farming systems. Natural farming has gained prominence in recent years. The National Mission for Natural Farming was introduced to formalise support through KVKs and a network of farmers. Despite growing institutional support, the transition to natural farming involves several dimensions, including farmer knowledge, skill development, access to bio-inputs, labour requirements, crop diversification, market access, perceived economic benefits and institutional support. Therefore, assessing the implementation and outcomes of natural farming interventions at the field level was important for understanding their effectiveness, scalability and sustainability. Evidence from farmer-level studies can help identify factors influencing adoption, assess changes in production economics and resource-use practices, and understand the environmental and livelihood implications of natural farming.

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Krishi Vigyan Kendras (KVKs) serve as important grassroots-level training and demonstration institutions for the implementation of Natural Farming (NF) under the National Mission on Natural Farming (NMNF). The NMNF framework envisages KVKs as training institutions responsible for developing NF model demonstration farms and supporting farmer-oriented capacity-building activities. The role of KVKs extends across demonstration, training, technical guidance, field-level handholding, capacity building and monitoring. The NF model demonstration farms were to be developed on the on-station plots of KVKs/AUs as well as farmers' fields. These farms provided a practical platform for demonstrating location-specific NF practices and for facilitating farmer exposure visits and hands-on learning. Crop diversification is an important component of such sustainable farming systems because diversification can reduce dependence on a single crop, improve resource-use efficiency, strengthen biological diversity and provide farmers with alternative sources of food and income. Diversification may occur through crop rotation, intercropping, inclusion of pulses and oilseeds, horticultural crops, millets, vegetables and other locally suitable crops. Recent ICAR initiatives have emphasized resource-based crop planning, crop and enterprise diversification and location-specific cropping choices as important elements of sustainable agricultural development. Evidence from farmer-level studies suggested that the sustainability of traditional and agro-ecological production systems depends on the interaction between ecological suitability, socio-cultural preferences and economic incentives (Yadav *et al.*, 2026) [2]. In Uttar Pradesh, the relevance of crop diversification is particularly important because of the predominance of cereal-based cropping systems and the diversity of agro-climatic conditions across the state. Diversification within natural farming demonstrations can provide an opportunity to examine how alternative crops and cropping arrangements perform under reduced external-input conditions. Earlier initiatives of KVKs in Uttar Pradesh have already emphasized intercropping, legumes, green manuring and avoidance of monocropping as components of sustainable crop production. Against this backdrop, the present study proposes to assess crop diversification in Natural Farming demonstrations established through KVKs in Uttar Pradesh. The study aims to document the crop portfolio under NF demonstrations, measure the degree of diversification, identify differences among KVKs and agro-climatic regions, and examine the institutional practices associated with diversification. The findings may provide useful evidence for strengthening location-specific NF demonstration models and designing more diversified and resilient natural farming systems in the state.

2. Methodology

2.1 Study area

The study was undertaken to assess the extent and pattern of crop diversification under Natural Farming (NF) demonstrations implemented through Krishi Vigyan Kendras (KVKs) in Uttar Pradesh during 2025–26. The primary source of information was the demonstration by KVKs for the Kharif, Rabi and Summer seasons of 2025–26. The study covered 60 KVKs and included information on KVK-level demonstrations, farmer-field demonstrations, participating farmers, seasons and crops planned under the NF demonstrations. Farmer-field demonstrations covered 0.5 acre per demonstration, while KVK-field demonstrations covered 1.0 acre. Across the three seasons, 541 demonstrations were reported, including 422 farmer-field demonstrations involving 234 farmers.

2.2 Unit of analysis

Three analytical units were considered

1. Demonstration level – to assess the number of crops included within individual NF demonstrations.
2. Farmer level – to assess the number and composition of distinct crops and crop groups adopted/planned by farmers across the seasons in which they hosted demonstrations.

3. KVK level – to assess variation in crop diversification among participating KVKs.

2.2 Crop Diversification: The crops were subsequently classified into broader crop groups, including: Cereals, Millets, Pulses, Oilseeds, Vegetables, Spices, Green manure, Commercial crops, Fruits, Flowers, Fodder. Green manure included Sun hemp, *Sesbania*,

Measurement of crop diversification

Crop diversification was assessed at both demonstration and farmer levels.

a. Crop richness: Crop richness was measured as the number of distinct crops represented in a given season or farmer's cropping portfolio:

$S = N$, where N represents the number of distinct crops.

b. Mean number of crops per demonstration

The average number of crops per demonstration was calculated as:

$$\bar{C} = \frac{\sum C_i}{n}$$

where C_i is the number of crops planned in demonstration i , and n is the number of demonstrations with crop information.

c. Shannon diversity index

The Shannon diversity index was used to quantify the diversity and distribution of crop:

$$H' = - \sum_{i=1}^S p_i \ln(p_i)$$

where p_i represents the proportion of crop cultivated belonging to crop i , and S is crop richness.

d. Simpson diversity index: Simpson diversity was expressed as:

$$D_s = 1 - \sum_{i=1}^S p_i^2$$

Higher values indicate greater diversity.

e. Pielou's evenness: Evenness was calculated as:

$$J = \frac{H'}{\ln(S)}$$

where H' is the Shannon diversity index, and S is the number of distinct crops. Higher values indicate a more even distribution of crops. The study also calculated dominance, expressed as the proportion of crops represented by the most frequently occurring crop. The dataset explicitly interprets higher Shannon, Simpson and evenness values as indicating greater diversity, while higher dominance indicates greater concentration in a single crop.

2.2.1. Farmer-level diversification classification

Farmers were classified according to the number of distinct crops represented across the seasons in which they hosted demonstrations:

- Low diversification: ≤ 2 crops
- Medium diversification: 3–5 crops
- High diversification: ≥ 6 crops

Crop-group diversification was also assessed by counting the number of distinct crop groups represented in each farmer's seasonal portfolio.

2.2.2. Seasonal crop transition

For farmers participating in consecutive seasons, changes in crop-group composition were examined between:

- Kharif $\rightarrow$ Rabi

- Rabi → Summer

For farmers participating in all three seasons, cropping sequences were constructed as follows: Kharif → Rabi → Summer. This enabled identification of recurring sequences such as Cereals → Cereals → Green manure and Cereals → Oilseeds → Green manure.

3. Results and discussion

3.1. Scale of natural farming demonstration by season

Table 1 presents the scale and seasonal spread of Natural Farming (NF) demonstrations conducted through KVKs in Uttar Pradesh during 2025–26. The programme covered 60 KVKs and implemented 541 demonstrations, comprising 119 KVK-field demonstrations and 422 farmer-field demonstrations, involving 234 farmers. The demonstrations therefore provided a substantial field-based platform for exposing farmers to Natural Farming practices under different seasonal conditions. The Rabi season recorded the largest number of demon-

strations (224), accounting for approximately 41.4% of all demonstrations, followed by Summer (168; 31.1%) and Kharif (149; 27.5%). The relatively greater Rabi coverage was accompanied by participation of 165 farmers and involvement of 56 KVKs, indicating broad institutional coverage during the season. In contrast, Kharif demonstrations were conducted through 43 KVKs, while Summer demonstrations involved 42 KVKs. The seasonal variation in coverage may reflect differences in crop calendars, availability of suitable demonstration opportunities and the operational scheduling of NF activities. The programme also demonstrated continuity beyond a single cropping season. Across the three seasons, 412 farmer-season participation records were generated, while the farmer-level data identified 234 farmers. Thus, the programme was not limited to one-time exposure for all participants; a considerable proportion of farmers participated in more than one season. This repeated engagement was relevant because agricultural extension interventions often required repeated interaction, field observation and reinforcement before farmers incorporate new practices into their production systems.

Table 1. Scale of natural-farming demonstrations by season.

Season	Number of KVKs	KVK-field demos	Farmer-field demos	Total demos	Number of farmers	Demo plot developed at KVK farm	Area of demos (acre) Gross cropped Area
Kharif	43	21	128	149	124	110	94.0
Rabi	56	56	168	224	165	100	95.9
Summer	42	42	126	168	123	167	139.9
All seasons	60	119	422	541	412	377	324.8

3.1.1. Farmer participation pattern across seasons

From the perspective of Natural Farming, the large number of demonstrations across three seasons is particularly important because NF involves a package of management practices rather than a single input or technology. Field demonstrations provide an opportunity for farmers to observe preparation and application of on-farm inputs, crop management, pest and disease management and other NF practices under local conditions. Repeated seasonal participation has particular relevance for crop diversification. Diversification is not necessarily a change within one season; it may occur through temporal diversification, whereby farmers cultivate different crops across successive seasons. Such diversification can contribute to risk distribution and reduce excessive dependence on a narrow crop portfolio (Chhatre *et al.*, 2016; Mihrete and Mihretu, 2025) [3, 4]. This interpretation was consistent with the broader literature suggesting that crop diversification can operate through spatial, temporal and crop-group dimensions and may contribute to resilience, resource-use efficiency and risk management (Mihrete *et al.*, 2025) [5]. A major finding was that 141 out of 234 farmers (60.3%) participated in at least two seasons, while 47 farmers (20.1%) participated across all three seasons. The mean number of seasons per farmer was 1.80, indicating that participation extended beyond a single seasonal exposure for a substantial proportion of beneficiaries. The largest individual participation category was Kharif + Rabi (50 farmers; 21.4%), followed by participation in all three seasons (47; 20.1%) and Rabi + Summer (40; 17.1%). Only 4 farmers (1.7%) participated in Kharif + Summer without Rabi participation. When the three single-season categories are considered together, 93 farmers (39.7%) participated in only one season, whereas 60.3% participated in two or three seasons.

Table 2. Farmer participation pattern across seasons

Participation pattern by season	Farmers (n)	% of farmers
Kharif only	27	11.5%
Rabi only	31	13.2%
Summer only	35	15.0%
Kharif + Rabi	50	21.4%
Rabi + Summer	40	17.1%
Kharif + Summer	4	1.7%

Table 2. Farmer participation pattern across seasons

Participation pattern by season	Farmers (n)	% of farmers
All three seasons	47	20.1%
Total	234	100.0%
Farmers in ≥ 2 seasons	141	60.3%
Mean seasons per farmer	1.80	

3.2 Crop diversification in natural farming

3.2.1. Cropping Pattern: Cereals dominated the two main seasons, present in 74.2% of Kharif and 77.0% of Rabi farmer-field demonstration with paddy and wheat the leading crops (Tables 3–4). It was observed that summer cultivation was for different purpose, green manuring (*Sunhemp* / *Sesbania*) appeared in 66.7% of summer demonstration, i.e. the summer window was used for soil-building rather than for a food crop. Pulses featured in 12.1%, 13.9% and 17.1% of demonstration in Kharif, Rabi and Summer respectively; oilseeds were mainly used in Rabi season (7.9%), and millets (11.3%) and vegetables (8.1%) were mainly of Kharif season.

This cereal dominance is important when interpreting diversification under NF. Natural Farming is conceptualized as an agroecology-based and diversified farming system in which crop diversity, soil cover, biomass recycling and integration of biological resources are important principles (NITI Aayog, 2026) [6]. The Natural Farming framework specifically recognizes crop diversity as an important component of the system and encourages maintaining diverse crops over the annual production cycle. Therefore, the predominance of paddy and wheat in the present demonstrations indicated that the transition towards Natural Farming does not necessarily imply an immediate replacement of dominant crops. Rather, diversification may initially occur through the introduction of additional crops or functional crops around the dominant cereal-based system. Crop diversification is influenced by agro-climatic suitability, market incentives, resource availability, food preferences and perceived production risks rather than by agronomic considerations alone (Chhatre *et al.*, 2016; Basantaray *et al.*, 2024; Yadav *et al.*, 2024) [7, 3, 4].

The ten most frequently planted crops (Table 4) further illustrate the concentration of the demonstration portfolio. Wheat accounted for 127 farmers field (27.6%), followed by paddy with 99 farmers field (21.5%) and green manure crops with 82 farmers field (17.8%).

Together, these three categories accounted for approximately 67% of all crop cultivated. This indicated that although a number of crop groups were represented, the overall crop portfolio remained concentrated around a few dominant crops and one important soil-building category. The high frequency of wheat and paddy suggests that the programme largely operated within farmers' established cereal-based cropping systems. This may be advantageous from an adoption perspective because introducing Natural Farming practices into familiar crops can reduce the behavioural and technical barriers associated with shifting to entirely unfamiliar crops. At the same time, the concentration indicated an opportunity for future NF demonstrations to systematically expand the representation of pulses, oilseeds, millets, vegetables and locally adapted crop varieties, particularly where agro-economic and market conditions permit.

The role of green manure as the third most frequent crop was noteworthy. Unlike wheat and paddy, green manure was not primarily in-

tended for direct food or market production in the reported demonstrations. Its high frequency therefore suggests that diversification under NF should be evaluated not only in terms of crop-count or market diversity, but also in terms of functional diversity. A farming system containing cereals, pulses, oilseeds, vegetables and biomass-producing green-manure crops may provide different ecological functions even if cereals remain numerically dominant. Overall, the findings demonstrated that crop diversification under Natural Farming demonstrations in Uttar Pradesh was season-specific and functionally differentiated. Kharif and Rabi remained strongly cereal-oriented, with paddy and wheat respectively dominating the crop portfolio, while Summer was substantially oriented towards green manuring. Pulses provided a relatively consistent diversification component across seasons, whereas millets, vegetables and oilseeds showed greater seasonal concentration.

Table 3. Crop-diversification on farmer-field demonstrations

Crop group	Kharif	Rabi 2025-26	Summer	All seasons
Farmer-field demos with crop (n)	124	165	123	412
Cereals	74.2%	77.0%	13.0%	57.0%
Millets	11.3%	0.0%	0.8%	3.6%
Pulses	12.1%	13.9%	17.1%	14.3%
Oilseeds	0.8%	7.9%	0.0%	3.4%
Vegetables	8.1%	5.5%	2.4%	5.3%
Spices	3.2%	1.8%	1.6%	2.2%
Green manure	0.0%	0.0%	66.7%	19.9%
Commercial	2.4%	0.0%	1.6%	1.2%
Fruits	0.8%	0.0%	0.0%	0.2%
Flowers	0.0%	0.6%	0.0%	0.2%
Fodder	0.0%	0.6%	0.0%	0.2%

Table 4. Ten most frequently planted crops in farmer-field demonstrations

Rank / Crop	Kharif (n)	Kharif (% demos)	Rabi (n)	Rabi (% demos)	Summer (n)	Summer (% demos)	Total	% of all crop cultivated
1. Wheat	0	0.0%	126	76.4%	1	0.8%	127	27.6%
2. Paddy (Rice)	88	71.0%	0	0.0%	11	8.9%	99	21.5%
3. Green manure (Dhaincha/Sunhemp)	0	0.0%	0	0.0%	82	66.7%	82	17.8%
4. Greengram (Moong)	3	2.4%	0	0.0%	16	13.0%	19	4.1%
5. Chickpea (Gram)	0	0.0%	17	10.3%	0	0.0%	17	3.7%
6. Blackgram (Urd)	8	6.5%	0	0.0%	6	4.9%	14	3.0%
7. Mustard	0	0.0%	13	7.9%	0	0.0%	13	2.8%
8. Maize	6	4.8%	1	0.6%	4	3.3%	11	2.4%
9. Barnyard millet (Sanwa)	6	4.8%	0	0.0%	0	0.0%	6	1.3%
10. Vegetables	5	4.0%	1	0.6%	0	0.0%	6	1.3%

3.2.2. Crop-diversification indices

3.2.2.1. Within-demo versus between-farmer diversity

The crop-diversification indices indicate that diversity in the Natural Farming (NF) programme emerged more strongly across farmers, KVKs and seasons than within individual farmer-field demonstrations. Across all seasons, 37 distinct crops belonging to 11 crop groups were recorded, resulting in an overall Shannon diversity index (H') of 2.381, Simpson diversity of 0.839 and Pielou's evenness of 0.659 (Table 5). However, the mean number of crops per individual demonstration was only 1.12, and 93.2% of demonstrations were single-crop demonstrations, while only 6.8% contained two or more crops. Thus, the programme exhibited considerable system-level crop diversity despite relatively low within-demonstration diversity. This

distinction was important in interpreting diversification under Natural Farming. A farming system may contain a relatively diverse crop portfolio at the programme or landscape level even when individual plots remain dominated by one crop. Recent evidence for India similarly demonstrates substantial spatial and temporal variation in crop diversity, with crop richness and diversity differing considerably among regions and over time (Sharma *et al.*, 2025) [8]. Therefore, assessing diversification only from the number of crops within an individual demonstration would underestimate the broader crop diversity represented across the NF programme. The present finding was also consistent with the conceptual understanding of Natural Farming as an agroecological transition in which diversification may occur through crop combinations, crop rotations and the integration of ecologically functional crops rather than necessarily through multiple

crops being grown simultaneously on every demonstration plot. A recent assessment of Natural Farming systems in central India similarly identifies crop diversification as one of the defining characteristics of the transition towards agroecological production systems (Thapa *et al.*, 2026) [9].

The difference between within-demo and between-farmer diversity is particularly evident from the richness measures. Although the overall programme represented 37 crops, the maximum number of crops recorded in a single demonstration was seven in Kharif and six in Rabi, while the summer maximum was four. Furthermore, only 1.0% of demonstrations across all seasons contained four or more crops. These results indicate that the observed programme-level diversity was generated primarily by the aggregation of different crop choices across farmers and seasons, rather than by highly diversified crop mixtures within individual demonstration plots. This pattern has practical implications for NF extension. The present demonstrations appear to provide a portfolio approach to diversification, whereby different KVKs and farmers demonstrate different crops according to season, agro-ecological suitability and local farming conditions. Such an approach can be valuable for extension because farmers are exposed to multiple crop options without necessarily requiring every demonstration to adopt a complex multi-crop system.

3.2.2.2. Seasonal variation in crop diversification

Marked seasonal differences were observed in the crop-diversification indices (Table 5). Kharif exhibited the highest Shannon diversity ($H' = 1.801$), Simpson diversity (0.630) and crop richness (22 crops), whereas Rabi recorded the lowest Shannon diversity ($H' = 1.293$), Simpson diversity (0.510) and Pielou's evenness (0.466). Summer occupied an intermediate position in Shannon diversity ($H' = 1.386$) and Simpson diversity (0.576), despite having the lowest crop richness among the three seasons (13 crops). The higher Kharif diversity reflects the comparatively broad crop portfolio during the monsoon season, including paddy, millets, pulses, vegetables, spices and other crops. In contrast, Rabi demonstrations were strongly concentrated around wheat. Wheat represented approximately 68.9% of all Rabi crop cultivated, resulting in a lower Shannon index and lower evenness. The lower diversity in Rabi therefore reflects not simply fewer crop types but, more importantly, greater concentration of the crop portfolio in one dominant crop. The relationship between crop richness and diversity is important here. Kharif had 22 distinct crops, whereas Rabi had 16; however, the difference in Shannon diversity was also influenced by the relative abundance of individual crops.

Shannon diversity incorporates both richness and proportional representation, so a season containing many crops can still have relatively low diversity if one crop dominates the observations. The high Rabi dominance of wheat provides a clear example of this phenomenon.

The Rabi results therefore demonstrate that crop richness alone is insufficient for characterizing diversification. The combination of Shannon diversity, Simpson diversity, Pielou's evenness and dominance provides a more informative assessment of the structure of the crop portfolio. The use of Shannon-Wiener and related indices is also well established in empirical assessments of crop diversification in India (Rai *et al.*, 2022) [10]. The Pielou's evenness index further reinforces this interpretation. Evenness was highest for the all-season dataset (0.659), followed by Kharif (0.583), Summer (0.541) and Rabi (0.466). The relatively low Rabi evenness indicates that the crop observations were distributed unevenly, with wheat accounting for a disproportionately large share. Conversely, the higher Kharif evenness indicates a comparatively more balanced distribution among the crops represented in the season. The dominance measure showed the same pattern. Dominance was 68.9% in Rabi, compared with 59.9% in Kharif and 63.1% in Summer. At the aggregate level, however, dominance declined substantially to 27.6%, because the pooling of observations across three seasons incorporated a much larger range of crops and reduced the proportional contribution of any single crop. This provides further evidence that the NF programme generated greater diversity across seasons than within individual seasonal crop portfolios. Summer presents an interesting case; it had the lowest crop richness (13 crops) and the lowest mean crops per demonstration (1.06), yet its diversity indices were not the lowest. This is because summer demonstrations were characterized by the presence of several crop groups, particularly the extensive use of green manure, rather than simply by a large number of different crops. Green manure accounted for 66.7% of summer demonstrations, primarily through *Dhaincha* and Sunhemp. Consequently, Summer diversification appears to have been driven partly by functional diversification, where a crop is included primarily for soil-building and ecological purposes rather than for direct food production. This functional dimension was particularly relevant to Natural Farming. Agroecological systems can derive benefits from crops that perform ecological functions such as biomass production, nutrient cycling, soil cover and biological regulation, even when such crops contribute little to marketable output. The role of crop diversification in strengthening soil health, biodiversity and resilience is increasingly recognized in assessments of agroecological farming systems (Sharma *et al.*, 2025) [8].

Table 5. Crop-diversification indices of farmer-field demonstrations by season

Indicator	Kharif	Rabi 2025-26	Summer	All seasons
Farmer-field demos with crop reported (n)	124	165	123	412
Mean crops per demo	1.19	1.11	1.06	1.12
Maximum crops in a single demo	7	6	4	7
% single-crop demos	89.5%	93.9%	95.9%	93.2%
% multi-crop demos (≥ 2 crops)	10.5%	6.1%	4.1%	6.8%
% demos with ≥ 4 crops	0.8%	1.2%	0.8%	1.0%
Crop richness (distinct crops, S)	22	16	13	37
Crop-group richness (distinct groups)	8	7	7	11
Shannon index (H')	1.801	1.293	1.386	2.381
Simpson diversity index ($1 - D$)	0.630	0.510	0.576	0.839
Pielou's evenness (J)	0.583	0.466	0.541	0.659
Dominance: share of most frequent crop	59.9%	68.9%	63.1%	27.6%

3.2.2.3. Farmer-level diversification and soil-fertility integration

Farmer-level diversification. Farmers plan on average 1.92 distinct crops and 1.55 crop groups across seasons; 79.9% fall in the low class (≤ 2 crops), 18.4% in the medium class (3–5) and 1.7% in the high

class (≥ 6) (Table 6). Only 9.0% of farmers combine three or more crop groups and 34.6% follow a rice/wheat-only plan (Table 7) – the main scope for further diversification.

Green manure for soil rejuvenation: It was observed that 33.3% of farmers combine a cereal/millet with a pulse or green-manure crop; green manure is used by 35.0% and pulses by 20.9% of farmers

(Table 7). Among farmers in all three seasons the commonest sequence is “Cereals → Cereals → Green manure” (34.0% of such farmers), i.e. cereal in Kharif and Rabi followed by a summer green-manure crop (Table 9B). Farmer reported in study of Uttar Pradesh Cultivating more crops each year and included green manure crop in crop cycle practicing crop rotation contributed to the yield and also restored soil fertility and enriched it with beneficial nutrients (Yadav *et al.*, 2021) [11]

Table 6. Farmer-level crop diversification (all seasons combined)

Indicator	Farmers (n)	% of farmers
A. Distinct crops per farmer		
1 crop	94	40.2%
2 crops	91	38.9%
3 crops	35	15.0%
4–5 crops	8	3.4%
6 or more crops	4	1.7%
Mean distinct crops per farmer	1.92	
Median distinct crops per farmer	2.0	
Maximum distinct crops (single farmer)	11	
B. Distinct crop groups per farmer		
1 group	132	56.4%
2 groups	79	33.8%
3 groups	14	6.0%
4 or more groups	7	3.0%
Mean crop groups per farmer	1.55	
C. Diversification class		
Low (≤ 2 crops)	187	79.9%
Medium (3–5)	43	18.4%
High (≥ 6)	4	1.7%

Distinct crops and crop groups per farmer across the seasons in which the farmer hosted demonstrations.

Table 8. Diversification by intensity of participation

Seasons covered	Farmers (n)	Mean distinct crops	Mean crop groups	% with pulses	% with green manure	% with vegetables	% Rice/Wheat-only
1 season	93	1.02	1.02	7.5%	25.8%	6.5%	47.3%
2 seasons	94	2.02	1.56	25.5%	30.9%	3.2%	36.2%
3 seasons	47	3.51	2.55	38.3%	61.7%	14.9%	6.4%

Table 9. Season-to-season crop change and cropping sequences

Cropping Pattern (Kharif → Rabi → Summer)	Farmers (n)	% of 3-season farmers
Cereals → Cereals → Green manure	16	34.0%
Pulses → Cereals → Green manure	4	8.5%
Cereals → Cereals → Cereals	3	6.4%
Cereals → Oilseeds → Green manure	3	6.4%
Cereals → Cereals → Pulses	2	4.3%

Table 7. Adoption of crop groups and soil-fertility components by farmers

Crops	Farmers (n)	% of farmers
Cereals	172	73.5%
Millets	15	6.4%
Pulses	49	20.9%
Oilseeds	14	6.0%
Vegetables	16	6.8%
Spices	8	3.4%
Green manure	82	35.0%
Commercial	3	1.3%
Fruits	1	0.4%
Flowers	1	0.4%
Fodder	1	0.4%
Cereal/millet + pulse or green-manure system	78	33.3%
Rice/wheat-only crop plan	81	34.6%
Farmers with ≥ 3 crop groups	21	9.0%

3.3. Participation intensity and diversification

Diversification increased with the number of seasons in which farmers participated. Mean distinct crops increased from 1.02 among one-season farmers to 3.51 among three-season farmers, while pulse inclusion increased from 7.5% to 38.3% and green-manure inclusion from 25.8% to 61.7%. Pasted markdown This suggests that repeated seasonal participation created greater opportunities for farmers to experiment with and adopt diverse crops.

3.3.1. Seasonal crop shifts and KVK-level variation

Crop-group composition changed for 46.4% of farmers between Kharif and Rabi and 87.4% between Rabi and Summer, with the latter transition largely reflecting cereal-to-green-manure shifts. Pasted markdown Considerable KVK-level variation was also observed, with mean distinct crops per farmer ranging from 1.0 to 8.0, indicating strong local heterogeneity in diversification patterns. Pasted markdown

Commercial → Cereals → Commercial	2	4.3%
Cereals → Oilseeds → Pulses	1	2.1%
Cereals → Cereals → Millets	1	2.1%
All other cropping pattern	15	31.9%

3.4. KVK-wise diversification of farmer field demonstration

Substantial variation was observed across KVKs in farmer-level crop diversification. Across 234 farmers, 37 distinct crops were recorded, with an overall mean of 1.92 crops per farmer. Pulses and green manure were included by 20.9% and 35.0% of farmers, respectively, while 34.6% followed rice/wheat-only patterns. Diversification varied

considerably among KVKs. Mirzapur recorded the highest mean of 8.00 distinct crops per farmer, followed by Bahraich-I (5.25) and Deoria (3.67). In contrast, several KVKs recorded only one distinct crop per farmer. Pasted markdown Pasted markdown. Pulses and green manure showed marked spatial variation. Pulse inclusion reached 100% of farmers in several KVKs, including Banda, Deoria, Hamirpur and Mirzapur, while green-manure adoption was particu-

larly high in Kanpur Dehat, Lalitpur, Pratapgarh, Prayagraj-I and Sitapur-II. The observed heterogeneity indicated that local conditions, farmer preferences and KVK-specific extension strategies influenced diversification patterns. Therefore, Natural Farming interventions may benefit from location-specific promotion of pulses, green manure and other locally suitable crops rather than adopting a uniform diversification strategy.

Table 10. KVK-wise diversification of farmer-field demonstrations

KVK/Districts	Farmers (n)	Farmer-field demos (n)	Distinct crops in KVK	Mean distinct crops per farmer	% farmers with pulses	% farmers with green manure	% farmers' rice/wheat-only
Agra	3	6	2	2.00	0.0%	0.0%	0.0%
Aligarh	4	9	5	2.25	50.0%	0.0%	0.0%
Amethi	3	6	2	2.00	0.0%	0.0%	100.0%
Amroha	6	9	2	1.00	0.0%	50.0%	50.0%
Azamgarh-I	3	9	2	2.00	0.0%	0.0%	100.0%
Baghpat	5	6	3	1.00	20.0%	20.0%	60.0%
Bahraich-I	4	9	12	5.25	50.0%	0.0%	0.0%
Ballia	4	6	3	1.50	0.0%	75.0%	0.0%
Balrampur	3	3	4	1.33	33.3%	0.0%	33.3%
Banda	3	6	3	2.00	100.0%	0.0%	0.0%
Barabanki	4	9	7	2.75	0.0%	50.0%	0.0%
Bareilly	4	6	2	1.50	0.0%	0.0%	100.0%
Basti	3	6	3	2.67	0.0%	0.0%	33.3%
Bijnor	3	6	2	2.00	0.0%	100.0%	0.0%
Budaun-I	7	9	4	1.29	0.0%	42.9%	42.9%
Bulandshahr	6	9	5	1.50	0.0%	50.0%	33.3%
Chandoli	4	6	2	1.50	0.0%	0.0%	100.0%
Chitrakoot	3	6	2	2.00	0.0%	0.0%	100.0%
Deoria	3	9	9	3.67	100.0%	33.3%	0.0%
Etah	5	9	4	1.80	40.0%	20.0%	40.0%
Etawah	3	3	1	1.00	0.0%	0.0%	100.0%
Fatehpur	5	9	3	1.80	60.0%	60.0%	0.0%
Gautam Buddha Nagar	3	3	1	1.00	0.0%	100.0%	0.0%
Ghaziabad	4	6	2	1.50	0.0%	0.0%	100.0%
Ghazipur-I	6	9	3	1.50	50.0%	50.0%	0.0%
Ghazipur-II	3	3	1	1.00	0.0%	100.0%	0.0%
Gonda-I	3	6	5	2.00	66.7%	0.0%	33.3%
Gorakhpur-II	3	3	1	1.00	0.0%	0.0%	100.0%
Hamirpur	3	6	2	2.00	100.0%	0.0%	0.0%
Hapur	3	3	1	1.00	0.0%	0.0%	100.0%
Hardoi-II	6	9	4	1.50	0.0%	33.3%	50.0%
Hathras	4	8	3	1.75	0.0%	75.0%	25.0%
Jalaun	3	6	1	1.00	0.0%	0.0%	100.0%
Jhansi	4	6	2	1.50	75.0%	0.0%	25.0%
Kannauj	3	3	2	1.00	0.0%	0.0%	33.3%
Kanpur Dehat	3	6	2	2.00	0.0%	100.0%	0.0%
Kasganj	5	9	8	2.40	60.0%	20.0%	0.0%
Kaushambi	3	9	4	3.00	0.0%	100.0%	0.0%
Kushinagar	6	9	5	1.83	0.0%	50.0%	16.7%
Lakhimpur Kheri-II	3	6	2	2.00	0.0%	100.0%	0.0%
Lalitpur	3	9	3	3.00	100.0%	100.0%	0.0%
Mahoba	3	3	1	1.00	0.0%	0.0%	100.0%
Mau	4	9	5	2.00	25.0%	25.0%	25.0%
Meerut	3	3	1	1.00	0.0%	0.0%	0.0%
Mirzapur	3	9	21	8.00	100.0%	33.3%	0.0%

(continued on next page)

Table 10. KVK-wise diversification of farmer-field demonstrations

KVK/Districts	Farmers (n)	Farmer-field demos (n)	Distinct crops in KVK	Mean distinct crops per farmer	% farmers with pulses	% farmers with green manure	% farmers' rice/wheat-only
Muzaffarnagar-II	3	9	4	2.33	0.0%	33.3%	0.0%
Pilibhit	6	9	3	1.50	0.0%	50.0%	50.0%
Pratapgarh	3	9	3	3.00	0.0%	100.0%	0.0%
Prayagraj-I (Allahabad)	3	9	5	3.33	33.3%	100.0%	0.0%
Raebareli-II	6	9	5	1.50	83.3%	0.0%	16.7%
Sant Kabir Nagar	4	9	5	2.50	0.0%	50.0%	25.0%
Sant Ravidas Nagar (Bhadohi)	3	3	1	1.00	0.0%	0.0%	100.0%
Shahjahanpur	6	9	4	1.50	16.7%	50.0%	50.0%
Shamli	3	6	2	2.00	0.0%	100.0%	0.0%
Siddharthnagar	6	9	2	1.17	0.0%	0.0%	66.7%
Sitapur-II	3	9	5	3.00	33.3%	100.0%	0.0%
Sonbhadra	3	6	2	2.00	0.0%	0.0%	100.0%
Sultanpur-I	3	9	4	3.00	0.0%	100.0%	0.0%
Unnao	5	9	8	2.40	60.0%	0.0%	20.0%
Varanasi	5	9	3	1.80	0.0%	60.0%	40.0%
All KVKs	234	422	37	1.92	20.9%	35.0%	34.6%

4. Conclusion

The study suggested that Natural Farming demonstrations could serve as an important entry point for promoting crop diversification, seasonal flexibility and greater use of pulses and green-manure crops. Future interventions should move beyond increasing the number of demonstrations alone and focus on strengthening within-farm diversification, locally suitable crop choices, farmer experimentation, multi-season participation and KVK-specific diversification strategies. At the same time, the findings are descriptive and should not be interpreted as evidence of a causal effect of Natural Farming on diversification. Long-term panel studies with appropriate comparison groups would be valuable for assessing whether these observed diversification patterns translate into sustained improvements in farm resilience, soil health, productivity and farm income.

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