Evaluation of Soil Physical Properties in Natural and Conventional Farming ~~Farmer~~ Practices in the Northern Dry Zone of Karnataka

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Abstract

This study examines ~~examined~~ variations in soil properties resulting from ~~both~~ natural and conventional farming methods across three distinct duration categories (less than 5 years, 5 to 10 years and 10 to 15 years) in the Northern Dry Zone of Karnataka. The results revealed that natural farming consistently produced lower soil bulk density, higher soil porosity, greater water-holding capacity and improved aggregate stability when compared to conventional farming practices. Over time, natural farming led to a decrease in bulk density; however, conventional practices showed an increase. Soil porosity, water-holding capacity and aggregate stability also saw improvement with natural farming because of the incorporation of organic matter, no-tillage methods and minimal disturbance. Conventional farming practices, which involved intensive tillage and the application of chemical inputs, resulted in soil compaction and structural degradation. Additionally, soil color became darker over time under natural farming, indicating a higher organic matter content; whereas, conventional practices contributed to lighter soil hues.

Keywords: *Soil Physical properties, Natural farming, Farmer Practices, Soil Color*

Introduction

The physical properties of soil are essential for comprehending the health and functionality of agricultural soils; this is especially true within the framework of natural farming and farmers practices. The characteristics of soil typically represent the initial step in assessing the condition and development of agricultural land, particularly within the context of natural farming or practices embraced by farmers. These attributes can significantly influence various functions, including water infiltration, root penetration, nutrient absorption and aeration. They are generally classified into several categories defined by texture, bulk density and porosity. Additionally, aggregate stability and water-holding capacity emerge as the most crucial physical properties of soil. Therefore, minimizing soil disturbance and incorporating organic matter into the soil (such as through mulching and the use of cover crops) can help preserve (or even enhance) many of these characteristics, ultimately leading to improved soil structure and an increased ability to retain water (Pinto *et al*., 2023). In arid regions, maintaining water retention becomes essential for boosting agricultural productivity in natural farming practices.

Practices adopted by conventional farmers-characterized by increased tillage, synthetic chemical applications and mono-cropping-exhibit detrimental effects on soil health. This heightened level of tillage frequently contributes to greater compaction, which consequently diminishes porosity and impedes root development (largely due to the pressures from chemical inputs). As a result, the organic matter incorporated into the soil undergoes degradation, leading to the destabilization of soil aggregates (Devarinti, 2016). When these farming systems are compared, their impact on soil health, water dynamics and overall productivity becomes evident (with long-term consequences that can potentially be quantified). However, the findings are promising for the design and extrapolation of various sustainable agricultural practices, which may optimize soil conditions for productivity (Agarwal and Agarwal, 2018). This approach is particularly vital in addressing the stresses encountered in challenging agricultural environments, although it requires careful consideration of all forms of resilience.

This research is particularly important in addressing the growing concerns of soil degradation caused by intensive agricultural practices. By assessing how natural farming known for its minimal external inputs and focus on organic methods affects soil properties relative to conventional methods, this study can provide evidence to guide farmers and policymakers toward sustainable agricultural practices. Additionally, understanding these impacts in the context of the dry zone’s climatic challenges can contribute to developing resilient farming systems that ensure food security, however, while preserving soil health for future generations. Although there are challenges, the potential for improvement remains significant because of the need for sustainable solutions.

Material and Methods

Location details

The research was carried out in three distinct natural farming clusters within the Belagavi district, situated in the Northern Dry Zone of Karnataka. These clusters were chosen based on a foundational survey associated with the Natural Farming project conducted during the 2018-19 period. Specifically, the clusters Shegunasi, Harugeri and Naganur are positioned at geo-coordinates 16.5679°N, 75.0567°E; 16.5164°N, 74.9498°E; and 16.3101°N, 74.9149°E, with corresponding altitudes of 547 m, 559 m and 625 m above sea level (respectively) and they belong to the hoblis of Athani, Arabhavi and Kudachi.

Farmers were classified into three distinct categories according to the length of time spent engaging in natural farming: those with less than 5 years of experience, 5–10 years and 10–15 years. A total of 20 farmers were selected from each of these groups. Soil samples were subsequently gathered not only from these farmers but also from their neighboring counterparts who practiced conventional farming. Additionally, these farmers were beneficiaries of the “CM Natural Farming” initiative within Zone 3 of Karnataka. However, the implications of these findings are complex, as they relate to the broader context of sustainable agriculture and local economies.

Soil sampling and processing

Soil samples were obtained from natural farming fields at a depth of 0–20 cm, encompassing three categories of farming experience: less than 5 years, 5–10 years and 10–15 years. Especially, 20 samples were collected from each category. Similarly, samples were gathered from neighboring fields that utilized conventional farming practices, with meticulous documentation of their management strategies for comparative analysis. The samples underwent shade-drying, were ground using a wooden pestle and mortar and were then sieved through a 2 mm mesh to prepare them for the analysis of various physical parameters. Bulk density was determined with a core sampler (Black, 1965), achieved by drying the soil at 105°C and calculating the density in Mg cm^{-3}. Soil color was identified using the Munsell Color Chart (Color, 1975), recording hue, value and chroma for both wet and dry samples. Porosity was calculated as a percentage of air and water space, with bulk and particle densities considered (Piper, 2002). Maximum water holding capacity was gauged by saturating the soil in a Keen’s cup and weighing it both wet and dry (Piper, 2002). The stability of soil aggregates was evaluated through the wet sieving technique, which aims to ascertain the presence of water-stable aggregates (Yoder & Robert, 1936; Kemper, 1965).

Statistical Analysis

Each of the soil properties were subjected to descriptive statistical analysis. Average, maximum and minimum value were calculated and tabulated. All values are expressed as mean values. Significant statistical differences between farming practices and among each category were established by the Tukey`s test (t test) at 1% level of significance (Gomez and Gomez, 1984).

Results and discussion

The study examined variations in soil bulk density under natural farming methods versus conventional farmers' practices across three distinct duration categories (less than 5 years, 5 to 10 years and 10 to 15 years) in the Northern Dry Zone of Karnataka, as illustrated in Table 1. Bulk density in natural farming fields was consistently lower than that observed in farmers' practice fields across all duration categories. For the period of less than 5 years of natural farming, bulk density varied from 1.25 to 1.40 Mg m^{-3}, while in farmers' practices, it ranged from 1.31 to 1.45 Mg m^{-3}, yielding mean values of 1.34 Mg m^{-3} and 1.40 Mg m^{-3}, respectively. Similarly, for the 5 to 10 years category, natural farming fields exhibited bulk density between 1.27 and 1.38 Mg m^{-3}, which was significantly lower than the values recorded for farmers' practices (1.31 to 1.53 Mg m^{-3}), with corresponding mean values of 1.32 Mg m^{-3} and 1.40 Mg m^{-3}. In the 10 to 15 years category, natural farming fields demonstrated bulk density ranging from 1.25 to 1.32 Mg m^{-3}, which was much lower than the farmers' practices (1.42 to 1.54 Mg m^{-3}), resulting in mean values of 1.28 Mg m^{-3} and 1.46 Mg m^{-3}, respectively. However, these findings highlight the potential benefits of natural farming, particularly in terms of maintaining lower soil bulk density over time. The bulk density of soil exhibited a significant decline over time in natural farming practices, decreasing from 1.34 Mg m^{-3} in less than five years to 1.28 Mg m⁻³ within a span of 10 to 15 years. Bulk density in conventional farmers practices rose from 1.40 Mg m⁻³ to 1.46 Mg m⁻³. This reduction in bulk density associated with natural farming is largely attributed to the implementation of no-tillage methods and the augmentation of organic matter, both of which enhance the stability and structure of soil aggregates. Numerous studies (for example, those conducted by Shepherd *et al*. 2002, Hati and Bandyopadhyay 2011; Chen and Wali, (2011) support this assertion. Organic matter enrichment, frequently realized through the application of farmyard manure and the incorporation of crop residues, has been shown to inversely correlate with bulk density, as noted by Black and Bauer (1983) and Sharma *et al*. (2000). However, the increase in bulk density observed in farmers' practices is linked to intensive tillage, which contributes to soil compaction and structural degradation. These results are consistent with the findings of Srikant *et al*. (2000), who indicated that higher bulk density was associated with the use of inorganic fertilizers rather than natural inputs. Furthermore, Kaje *et al*. (2018) noted that long-term natural farming practices resulted in lower bulk density, attributable to the cumulative addition of organic matter that enhances soil structure.

Table 1. Influence of natural farming and farmers practices on soil bulk density (<5, 5-10 and 10-15 years)

SL.No	**Bulk Density (Mg m^{-3})**					
	<5 years		**5-10 years**		**10-15 years**	
	NF	**FP**	**NF**	**FP**	**NF**	**FP**
1	1.33	1.40	1.36	1.45	1.26	1.42
2	1.35	1.40	1.32	1.41	1.25	1.49
3	1.36	1.42	1.37	1.42	1.30	1.51
4	1.30	1.39	1.38	1.53	1.29	1.49
5	1.35	1.38	1.28	1.31	1.28	1.47
6	1.34	1.39	1.35	1.49	1.26	1.46
7	1.35	1.43	1.32	1.47	1.28	1.44
8	1.39	1.45	1.35	1.45	1.27	1.49
9	1.35	1.43	1.30	1.40	1.28	1.54
10	1.26	1.40	1.35	1.43	1.25	1.43
11	1.25	1.31	1.30	1.44	1.29	1.43
12	1.40	1.45	1.32	1.38	1.28	1.44
13	1.34	1.35	1.27	1.40	1.29	1.43
14	1.37	1.38	1.35	1.45	1.32	1.49
15	1.35	1.39	1.29	1.43	1.27	1.44
16	1.27	1.33	1.35	1.45	1.26	1.42
17	1.33	1.45	1.28	1.38	1.28	1.54
18	1.34	1.39	1.32	1.44	1.29	1.44
19	1.33	1.37	1.31	1.42	1.27	1.42
20	1.35	1.39	1.30	1.34	1.31	1.44
Mean	**1.34**	**1.40**	**1.32**	**1.42**	**1.28**	**1.46**
Max	1.40	1.45	1.38	1.53	1.32	1.54
Min	1.25	1.31	1.27	1.31	1.25	1.42
S.D	0.04	0.04	0.03	0.05	0.02	0.04
C.V	2.92	2.70	2.44	3.47	1.46	2.65
For comparison between farming practices in different years						
t stat. values	7.87		12.06		20.14	
P=0.01	< 0.01		< 0.01		< 0.01	
Remarks	S		S		S	
For comparison between years						
	< 5yr	5-10 yrs	5-10 yrs	10-15 yrs	< 5yr	10-15 yrs
Natural farming						
t stat. values	1.16		4.80		6.18	
P=0.01	0.130		<0.01		<0.01	
Remarks	NS		S		S	

Farmers practice			
t stat. values	1.86	2.71	8.45
P=0.01	0.04	<0.01	<0.01
Remarks	NS	S	S

The data concerning soil porosity in relation to natural farming and farmers' practices across three distinct farming duration categories is encapsulated in Table 2. In fields where natural farming had been implemented for less than 5 years, porosity fluctuated between 47.17% and 52.83%, which is significantly higher than the values observed under farmers' practices (ranging from 45.28% to 50.57%). The mean values for these two practices were 49.65% and 47.53%, respectively. For the 5 to 10-year duration, natural farming exhibited porosity values between 47.92% and 52.83%, while farmers practices had a range of 44.26% to 50.57%, with mean values of 50.45% and 46.59%, respectively. In fields subjected to 10 to 15 years of natural farming, porosity ranged from 50.19% to 52.83%, again significantly surpassing the farmers practices, which yielded values of 41.89% to 49.43%, with corresponding mean values of 51.74% and 45.23%. Notably, porosity experienced a substantial increase under natural farming over time (from 49.65% for less than 5 years to 51.74% for 10 to 15 years), whereas it declined under farmers' practices (from 47.53% to 45.23%). This enhancement in porosity associated with natural farming can be attributed to the long-term addition of organic matter, which improves aggregate stability and decreases bulk density (Teixeira *et al*., 2021). The practices of farmers have reduced porosity (due to heavy machinery use), which consequently leads to soil compaction and a decrease in larger pores (Bakker & Davis, 1995). The inverse relationship between bulk density and porosity is evident; this is reported by Hao *et al*. (2008) and Wortman *et al*. (2012) in organic systems. However, natural farming consistently demonstrates higher porosity across all durations (when compared to conventional practices).

Table 2. Influence of natural farming and farmers practices on Porosity (<5, 5-10 and 10-15 years)

SL.No	Porosity (%)					
	<5 years		5-10 years		10-15 years	
	NF	**FP**	**NF**	**FP**	**NF**	**FP**
1	49.81	47.17	48.67	45.28	52.45	46.42
2	49.06	47.17	50.94	46.79	52.83	43.77
3	48.68	46.42	48.30	46.42	50.94	43.02
4	50.94	47.55	47.92	44.26	51.32	47.55
5	49.06	47.92	51.65	50.57	51.70	44.53
6	49.43	47.55	49.06	44.77	52.45	44.91
7	49.06	46.04	50.19	44.53	51.70	45.66
8	47.55	45.28	49.06	45.28	52.08	43.77
9	49.56	49.06	49.43	49.06	51.70	41.89
10	52.45	47.17	52.08	46.04	52.83	46.04
11	52.83	50.57	52.08	45.66	51.32	46.14
12	47.17	45.28	50.19	47.92	51.70	45.66
13	49.93	49.43	52.83	47.17	51.32	46.04
14	48.30	47.92	49.06	45.28	50.19	43.77
15	49.06	47.55	51.32	46.04	52.08	45.66
16	52.07	49.81	49.06	45.28	52.45	46.42
17	49.81	45.28	51.71	47.92	51.70	41.89
18	49.43	47.55	50.19	45.66	51.32	49.43
19	49.81	48.30	52.83	47.17	52.08	46.42
20	49.06	47.55	50.57	49.43	50.57	45.66
Mean	**49.65**	**47.53**	**50.45**	**46.59**	**51.74**	**45.23**
Max	52.83	50.57	52.83	50.57	52.83	49.43
Min	47.17	45.28	47.92	44.26	50.19	41.89
S.D	1.47	1.46	1.52	1.72	0.70	1.47
C.V	2.95	3.07	3.01	3.70	1.36	2.95

For comparison between farming practices in different years						
t stat. values	7.22		9.39		6.02	
P=0.01	< 0.01		< 0.01		< 0.01	
Remarks	S		S		S	
For comparison between years						
	< 5yr	5-10 yrs	5-10 yrs	10-15 yrs	< 5yr	10-15 yrs
Natural farming						
t stat. values	7.22		3.61		6.02	
P=0.01	< 0.01		<0.01		< 0.01	
Remarks	S		S		S	
Farmers practice						
t stat. values	1.83		2.08		5.08	
P=0.01	0.04		<0.01		< 0.01	
Remarks	NS		S		S	

The maximum water holding capacity (MWHC) of soil under natural farming and farmers' practices, categorized across three distinct farming durations, is encapsulated in Table 3. In fields subjected to less than five years of natural farming, the MWHC fluctuated between 46.24% and 53.57%, which is notably higher than the range observed under farmers' practices (45.78% to 50.77%). The mean values were 49.85% and 47.68%, respectively. For the duration of 5 to 10 years, the MWHC under natural farming exhibited variation from 48.42% to 53.33%, in contrast to the 42.46% to 50.77% measured in farmers' practices; mean values here were 50.99% and 46.66%, respectively. In fields where natural farming had been practiced for 10 to 15 years, MWHC ranged from 50.64% to 53.28%, again significantly higher than the 42.24% to 46.77% found in farmers' practices, with mean values of 52.19% and 45.20%. Over time, MWHC increased considerably under natural farming from 49.85% for less than five years to 52.19% for 10 to 15 years while it decreased under farmers' practices, dropping from 47.68% to 45.20%. Although the differences in MWHC were significant across the years for both farming systems, they were not significant between the periods of less than five years and five to ten years in either system. The elevated MWHC observed in natural farming can be credited to an increase in soil organic matter (SOM). This enhancement contributed to better soil structure, as well as improved micro- and macro-porosity, ultimately leading to a greater water retention capacity (Droogers *et al*., 1996). The addition of organic matter via natural farming, coupled with its microbial decomposition, significantly altered the distribution of pore sizes. Thus, it enhanced both water storage and transport within the soil. Similar findings were noted by Yunchen Zhao *et al*. (2009), who emphasized the beneficial effect of organic inputs on the soil's water-holding capacity. However, the complexities of these interactions necessitate further examination.

Table 3. Influence of natural farming and farmers practices on Maximum water holding capacity (<5, 5-10 and 10-15 years)

SL.No	MWHC (%)					
	<5 years		**5-10 years**		**10-15 years**	
	NF	**FP**	**NF**	**FP**	**NF**	**FP**
1	50.31	47.37	52.95	45.48	52.90	46.77
2	49.26	47.67	51.44	46.99	53.18	44.12
3	48.88	46.92	48.80	46.62	51.39	43.37
4	51.44	48.05	48.42	42.46	51.77	44.12
5	49.26	48.42	52.28	50.77	52.15	44.88
6	49.93	47.75	49.56	45.27	52.90	45.26
7	49.56	46.24	50.69	44.73	52.15	46.01
8	47.67	45.88	50.23	45.48	52.53	44.12
9	46.24	46.04	49.63	49.56	52.15	42.24
10	52.65	47.67	52.85	46.24	53.28	46.39
11	53.33	50.77	52.58	45.86	51.77	46.40
12	47.37	45.78	50.69	48.12	52.15	46.01
13	49.26	49.06	53.33	47.37	51.77	46.39

14	48.80	48.12	49.56	45.48	50.64	44.12
15	49.56	47.75	51.82	46.24	52.53	46.01
16	53.57	50.31	49.56	45.48	52.90	46.77
17	50.01	45.78	52.25	48.12	52.15	42.24
18	49.93	47.75	50.69	45.86	51.77	46.01
19	50.31	48.50	53.33	47.37	52.53	46.77
20	49.56	47.75	51.07	49.63	51.02	46.01
Mean	**49.85**	**47.68**	**50.99**	**46.66**	**52.19**	**45.20**
Max	53.57	50.77	53.33	50.77	53.28	46.77
Min	46.24	45.78	48.42	42.46	50.64	42.24
S.D	1.84	1.37	1.54	1.92	0.70	1.46
C.V	3.68	2.88	3.01	4.11	1.35	3.23
For comparison between farming practices in different years						
t stat. values	7.30		9.73		20.42	
P=0.01	< 0.01		< 0.01		< 0.01	
Remarks	S		S		S	
For comparison between years						
	< 5yr	5-10 yrs	5-10 yrs	10-15 yrs	< 5yr	10-15 yrs
Natural farming						
t stat. values	2.36		3.36		5.48	
P=0.01	0.015		<0.01		< 0.01	
Remarks	NS		S		S	
Farmers practice						
t stat. values	1.64		2.68		8.45	
P=0.01	0.06		<0.01		< 0.01	
Remarks	NS		S		S	

The aggregate stability of soil at a depth of 0–20 cm, assessed under both natural farming and traditional farmers' practices across three distinct farming duration categories, is delineated in Table 4. In the case of natural farming (<5 years), aggregate stability exhibited a range from 51.37% to 58.07%, which is significantly higher than the farmers' practices, where stability ranged from 50.24% to 54.81%. The mean values were 54.39% for natural farming and 51.89% for farmers' practices, respectively. For the 5–10 year period, natural farming displayed aggregate stability between 53.30% and 57.83%, in contrast to the 46.46% to 54.77% observed under farmers' practices; the mean values being 55.53% and 50.94%, respectively. In the 10–15 year timeframe, natural farming values ranged from 55.14% to 57.78%, significantly exceeding the farmers' practices, which ranged from 46.54% to 51.07%, with mean values of 56.69% and 49.51%, respectively. Aggregate stability demonstrated an upward trend over time under natural farming, increasing from 54.39% (<5 years) to 56.69% (10–15 years), while a decline was noted in farmers' practices, dropping from 51.89% (<5 years) to 49.51% (10–15 years). The differences in aggregate stability within natural farming were significant between the 5–10 and 10–15 year periods, as well as between <5 and 10–15 years; however, they were non-significant between <5 and 5–10 years. In a similar, notable disparities were identified in farmers practices when comparing <5 and 10–15 years; however, no such differences were found among other categories. The enhanced aggregate stability observed in natural farming, especially in the 10–15 year range, can be attributed to the long-term incorporation of organic matter, no-till practices and root activity that fosters macro-aggregate consolidation. Organic matter serves as a vital cementing agent, thereby improving stability through the formation of clay-organic matter complexes. In contrast, the tillage methods and chemical fertilizers employed in conventional farmers' practices tend to disrupt aggregates and diminish organic matter content. These observations are consistent with research conducted by Tisdall and Oades (1982), Yousefi *et al*. (2008), Williams *et al*. (2017) and Kaje *et al*. (2018), all of which highlight the importance of organic matter and minimal disturbance in enhancing soil aggregate stability.

Table 4. Influence of natural farming and farmers practices on aggregate stability (<5, 5-10 and 10-15 years)

SL.No	**Aggregate stability (%)**					
	<5 years		**5-10 years**		**10-15 years**	
	NF	**FP**	**NF**	**FP**	**NF**	**FP**

1	54.81	51.37	57.45	49.48	57.40	51.07
2	53.26	52.17	55.94	50.99	56.78	48.42
3	52.88	51.42	53.70	50.62	55.89	47.67
4	55.94	51.55	53.30	46.46	56.27	48.62
5	53.26	52.92	57.08	54.72	56.65	49.18
6	54.43	51.75	54.06	49.97	57.40	49.56
7	54.06	50.25	55.19	48.73	56.65	50.31
8	52.17	50.48	54.83	49.48	57.03	48.42
9	54.06	50.54	54.06	53.63	56.65	46.54
10	56.65	52.17	57.10	50.24	57.78	50.69
11	57.83	54.77	57.08	49.86	56.27	50.70
12	51.37	50.24	55.19	52.12	56.65	50.31
13	54.43	53.26	57.83	54.77	56.27	50.69
14	53.30	52.12	54.06	49.48	55.14	48.42
15	54.06	51.75	56.32	50.24	57.03	50.31
16	58.07	54.81	54.06	49.48	57.40	51.07
17	54.01	50.28	56.75	52.12	56.65	46.54
18	54.43	51.75	55.19	49.86	56.27	50.31
19	54.81	52.50	57.83	51.37	57.03	51.07
20	54.06	51.75	55.57	53.63	55.52	50.31
Mean	**54.39**	**51.89**	**55.53**	**50.94**	**56.69**	**49.51**
Max	58.07	54.81	57.83	54.77	57.78	51.07
Min	51.37	50.24	53.30	46.46	55.14	46.54
S.D	1.68	1.32	1.48	2.11	0.70	1.46
C.V	3.10	2.53	2.65	4.15	1.24	2.94
For comparison between farming practices in different years						
t stat. values	8.80		10.60		21.03	
P=0.01	< 0.01		< 0.01		< 0.01	
Remarks	S		S		S	
For comparison between years						
	< 5yr	5-10 yrs	5-10 yrs	10-15 yrs	< 5yr	10-15 yrs
Natural farming						
t stat. values	2.39		3.31		5.75	
P=0.01	0.014		<0.01		< 0.01	
Remarks	NS		S		S	
Farmers practice						
t stat. values	1.72		2.46		8.01	
P=0.01	0.05		0.012		< 0.01	
Remarks	NS		NS		S	

The impact of natural farming and the practices employed by farmers on soil coloration across three distinct farming duration categories (<5, 5–10 and 10–15 years) is illustrated in Table 5. Soil color varied from a deep gray to black; however, darker shades were more prevalent under natural farming compared to conventional farmers' practices. In the realm of natural farming, soil darkness augmented over time, following the sequence: 10–15 years > 5–10 years > <5 years. Conversely, in farmers practices, the soil exhibited a trend towards lighter hues as time progressed (5–10 years > 10–15 years > <5 years). This darker soil associated with natural farming can be attributed to a greater organic matter (OM) content, which arises from the application of compost, green manure and crop residues. These elements contribute to humus formation through microbial decomposition. Although humus itself is typically dark brown or black, it plays a crucial role in enhancing soil color, structure and fertility, while also improving moisture retention—especially when the soil is moist (Schmidt *et al*., 2011; Gerhardt, 1997). The practices of farmers that involve synthetic fertilizers, pesticides and intensive tillage tend to diminish OM levels,

Table 5. Influence of natural farming and farmers practice on Soil colour (<5, 5-10 and 10-15 years)

SL. No	Soil colour											
	0-5 years				5-10 years				10-15 years			
	NF		FP		NF		FP		NF		FP	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
1	7.5YR 3/2	7.5YR2.5/1	7.5YR4/2	7.5YR2.5/1	7.5YR2.5/3	7.5YR2.5/1	7.5YR4/1	7.5YR2.5/2	7.5YR2.5/2	7.5YR2.5/1	7.5YR4/1	7.5YR2.5/2
2	7.5YR 3/2	7.5YR2.5/1	7.5YR4/1	7.5YR2.5/2	7.5YR3/1	7.5YR2.5/2	7.5YR4/1	7.5YR2.5/2	7.5YR2.5/2	7.5YR2.5/1	7.5YR3/2	7.5YR2.5/3
3	7.5YR 3/2	7.5YR2.5/1	7.5YR3/1	7.5YR2.5/1	7.5YR2.5/2	7.5YR2.5/1	7.5YR4/1	7.5YR2.5/2	7.5YR3/2	7.5YR2.5/1	7.5YR4/1	7.5YR2.5/3
4	7.5YR 3/2	7.5YR2.5/1	7.5YR3/1	7.5YR2.5/1	7.5YR2.5/2	7.5YR2.5/2	7.5YR3/1	7.5YR2.5/2	7.5YR3/2	7.5YR2.5/3	7.5YR4/1	7.5YR2.5/3
5	7.5YR 3/2	7.5YR2.5/1	7.5YR3/1	7.5YR2.5/1	7.5YR3/2	7.5YR3/2	7.5YR3/2	7.5YR2.5/3	7.5YR2.5/2	7.5YR2.5/1	7.5YR3/1	7.5YR2.5/1
6	7.5YR 3/2	7.5YR2.5/1	7.5YR3/1	7.5YR2.5/2	7.5YR3/2	7.5YR2.5/2	7.5YR4/1	7.5YR2.5/2	7.5YR2.5/3	7.5YR2.5/1	7.5YR3/2	7.5YR2.5/1
7	7.5YR 3/2	7.5YR2.5/1	7.5YR3/2	7.5YR2.5/1	7.5YR3/1	7.5YR2.5/2	7.5YR4/1	7.5YR2.5/2	7.5YR4/2	7.5YR3/2	7.5YR4/1	7.5YR2.5/3
8	7.5YR 3/2	7.5YR2.5/1	7.5YR3/1	7.5YR2.5/1	7.5YR3/2	7.5YR2.5/1	7.5YR3/1	7.5YR2.5/1	7.5YR3/3	7.5YR2.5/2	7.5YR3/2	7.5YR2.5/3
9	7.5YR 3/2	7.5YR2.5/1	7.5YR3/1	7.5YR2.5/2	7.5YR2.5/2	7.5YR2.5/1	7.5YR4/1	7.5YR2.5/3	7.5YR3/2	7.5YR2.5/2	7.5YR3/1	7.5YR2.5/2
10	7.5YR 3/2	7.5YR2.5/1	7.5YR3/1	7.5YR2.5/2	7.5YR2.5/3	7.5YR2.5/2	7.5YR4/1	7.5YR2.5/3	7.5YR2.5/3	7.5YR2.5/1	7.5YR3/1	7.5YR2.5/2
11	7.5YR3/3	7.5YR3/2	7.5YR3/1	7.5YR2.5/1	7.5YR3/4	7.5YR3/3	7.5YR3/1	7.5YR2.5/2	7.5YR2.5/3	7.5YR2.5/1	7.5YR4/3	7.5YR4/2
12	7.5YR3/3	7.5YR3/2	7.5YR3/1	7.5YR2.5/1	7.5YR3/4	7.5YR3/3	7.5YR3/3	7.5YR2.5/3	7.5YR2.5/3	7.5YR2.5/1	7.5YR4/3	7.5YR4/2
13	7.5YR3/3	7.5YR3/2	7.5YR3/1	7.5YR2.5/1	7.5YR3/4	7.5YR3/3	7.5YR3/3	7.5YR2.5/3	7.5YR2.5/3	7.5YR2.5/1	7.5YR4/1	7.5YR2.5/2
14	7.5YR3/3	7.5YR3/2	7.5YR3/1	7.5YR2.5/1	7.5YR3/4	7.5YR3/3	7.5YR3/3	7.5YR2.5/3	7.5YR2.5/3	7.5YR2.5/1	7.5YR4/3	7.5YR2.5/2
15	7.5YR3/3	7.5YR3/2	7.5YR3/1	7.5YR2.5/1	7.5YR4/3	7.5YR3/4	7.5YR4/1	7.5YR3/2	7.5YR2.5/3	7.5YR2.5/1	7.5YR4/3	7.5YR2.5/2
16	7.5YR3/3	7.5YR3/2	7.5YR3/1	7.5YR2.5/1	7.5YR4/3	7.5YR3/4	7.5YR4/1	7.5YR3/2	7.5YR2.5/3	7.5YR2.5/1	7.5YR4/4	7.5YR2.5/2
17	7.5YR3/3	7.5YR3/2	7.5YR3/1	7.5YR2.5/1	7.5YR4/3	7.5YR3/4	7.5YR4/1	7.5YR3/2	7.5YR3/2	7.5YR2.5/1	7.5YR4/2	7.5YR2.5/2
18	7.5YR3/4	7.5YR2.5/3	7.5YR3/3	7.5YR2.5/3	7.5YR4/3	7.5YR3/4	7.5YR4/1	7.5YR3/2	7.5YR3/2	7.5YR2.5/1	7.5YR4/1	7.5YR2.5/2
19	7.5YR 3/2	7.5YR2.5/1	7.5YR3/1	7.5YR2.5/3	7.5YR4/3	7.5YR3/4	7.5YR4/1	7.5YR3/2	7.5YR3/2	7.5YR2.5/1	7.5YR4/1	7.5YR2.5/2
20	7.5YR2.5/2	7.5YR2.5/1	7.5YR3/1	7.5YR2.5/3	7.5YR2.5/3	7.5YR2.5/1	7.5YR3/2	7.5YR2.5/2	7.5YR3/2	7.5YR2.5/1	7.5YR4/2	7.5YR2.5/2

- 7.5YR3/1-very dark gray
- 7.5YR4/1- Dark gray
- 7.5YR4/2- Brown
- 7.5YR3/2,7.5YR3/3, 7.5YR3/4- dark brown
- 7.5YR2.5/2, 7.5YR2.5/3 - very dark brown
- 7.5YR2.5/1- Black

compromise soil structure and reduce moisture retention, ultimately leading to a decrease in microbial activity. This process results in lighter soil colors over time (Tilman *et al*., 2002). The more pronounced darker soils seen over a period of 10–15 years in natural farming illustrate the cumulative advantages of sustained organic inputs and minimal disturbance. This is consistent with the findings from Glover *et al.* (2000), Doran and Zeiss (2000) and Lal (2006). However, it is important to note that these benefits may not be immediately apparent, because they develop gradually. Although the research supports these assertions, further studies would strengthen the argument.

Conclusion

The research highlights the significant advantages of natural farming in contrast to conventional approaches, particularly in terms of enhancing soil health indicators (such as bulk density, porosity, water-holding capacity, aggregate stability and soil color). Over time, natural farming has displayed a consistent trend: lower bulk density, increased porosity, enhanced water retention and superior aggregate stability. This can be attributed to various factors, including the long-term integration of organic matter, no-tillage practices and reduced soil disturbance. However, conventional farming, often linked to intensive tillage and synthetic inputs, leads to soil compaction, decreased porosity and compromised aggregate stability. Although natural farming has resulted in darker soils suggestive of higher organic matter content it also improves soil fertility and moisture retention. These findings emphasize the potential of natural farming to not only sustain but also enhance soil quality, thus offering a promising option for long-term agricultural sustainability.

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