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Soil Quality Evaluation and Dominant Factor Analysis of Economic Forest in Loess Area of Northern Shaanxi

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Abstract: Choosing economically important trees and establishing planting patterns can improve soil quality in economic forests. To clarify the soil quality status of the main economic forest land distributed in northern Shaanxi, the research object in this study was jujube and apple economic forests, and the control was grassland. By evaluating 17 soil indicators, the minimum data set (MDS) and structural equation model (SEM) were used to analyze the soil quality status and its dominant factors under different economic forests and land preparation methods. The results showed that (1) compared with grassland, the economic forest has a certain improvement and promotion in soil's properties, mainly in the water-holding capacity and available nutrients. Compared to the undisturbed slope, the level bench had better physical and chemical properties. (2) Six indicators were identified as the minimum data set for assessing soil quality, including the soil organic carbon, saturated water content, bulk density, alkaline nitrogen, sand, and total capillary porosity. In addition, structural equation model analysis showed that the soil organic carbon, saturated water content, alkaline nitrogen, and capillary porosity were the dominant factors affecting soil quality in the study area. (3) Jujube trees exhibited the highest soil quality and the best restoration effect, followed by apple trees, while grassland had the poorest restoration effect. The soil quality of undisturbed slopes under different land preparation methods was lower than that of the level bench land preparation. The outcomes of this study are to provide data support and a theoretical basis for improving soil quality, enhancing ecological benefits, and selecting and managing economic forest species, in the study area and similar regions in the future.

Keywords: apple tree; jujube tree; land preparation methods; minimum data set; structural equation modeling

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1. Introduction

Soil is an important part of terrestrial ecosystems, a critical carrier for maintaining the survival and development of animals and plants [1], and the basis of plant growth [2]. However, factors such as insufficient precipitation, severe soil erosion, sparse vegetation, and others can hurt soil, thereby reducing soil quality and productivity. As a typical area in the loess area of northern Shaanxi [3–5], in recent years, the implementation of returning farmland to the forest (grass) and another forestry ecological engineering construction, as well as the use of artificial afforestation, aerial seeding afforestation, and closed forest ecological restoration measures, have been implemented [6]. The soil quality in the study area has been improved, and the ecological benefits have been significantly enhanced. Soil quality is important for maintaining biological production, protecting environmental quality, and promoting animal and plant health. It is also a powerful tool for revealing soil degradation and ecosystem health [7].

Soil quality can reflect the soil management and production capacity [8]. Owing to its complex soil structure and rich functions, a single soil indicator evaluation cannot fully and accurately represent the comprehensive characteristics of the soil. It is necessary to comprehensively evaluate the physical, chemical, and biological characteristics to increase the accuracy of the evaluation [9]. In recent years, many researchers have conducted extensive research on soil quality evaluation methods [10–12]. Model methods, such as vague mathematics and dimensionality reduction, have been introduced into soil quality research at different spatial and temporal scales including ecological restoration areas, artificial forest land, and mixed forest land [13,14]. The soil quality index method, which is a more objective and practical method for evaluating soil quality, has been widely used by researchers [15,16], mainly for the sustainable development of grassland, farmland, and forest land [17,18]. Tian et al. [19] used principal component analysis to evaluate the relationship between the soil quality evaluation indicator (SQI) and crop yield in maize and wheat fields based on the minimum data set. The results showed that the SQI played an important role in improving the crop yield and had an essential guiding significance for the management and practice of the SQI in later stages. Scholars evaluated the potential of different vegetation types by studying their effects on the soil quality under drought stress and in wetland ecosystems, providing references for future vegetation selection [20,21]. Currently, research on soil quality evaluation mostly focuses on conventional arbor forest land or shrub forest land [22,23], and pays more attention to ecological benefits. The research objectives include different land use and management methods, soil types, natural vegetation restoration models [24–27], and so on. Studies on the soil quality of economic forest land under different land preparation methods in the loess area have been comparatively scarce. However, since the project of returning farmland to the forest (grass) was carried out in 1999, jujube and apple trees have been planted in large areas as economically important forest tree species for soil erosion control in loess hilly areas and as an important industrial basis for farmers in poor mountainous areas to eliminate poverty and become rich [28,29]. A previous study showed that the area of economic forests has reached 947,000 hm^2 in northern Shaanxi [30], but studies on economic forests have mainly focused on the economic cost, planting layout, and planting mode. Few studies have evaluated the soil quality of economic forests, and the differences in soil quality among different economic forest species are even smaller in the loess area of northern Shaanxi. Strengthening monitoring and research on the soil quality of economic forest land has important significance for the selection of suitable tree species, the establishment of planting patterns in the process of economic forest construction in the study area, and promoting the sustainable development of economic forest land. Therefore, we hypothesize that the physicochemical properties of soil evaluation indexes are differentiated under different vegetation types as well as different land preparation methods and have important effects on the soil quality in the study area. In view of this, this study aims (1) to investigate the differences in soil quality evaluation indicators among different vegetation types; (2) to explore the quality of the soil under different vegetation types and land preparation methods by calculating the soil quality index, and establish a minimum data set suitable for soil quality evaluation in the study area; (3) to identify the major soil factors that affect the soil quality in the study area.

2. Materials and Methods

2.1. Study Area

The Qijiashan jujube experimental demonstration base (36°57′ N, 110°29′ E) is located in the northeast of Yan'an City, Shaanxi Province, China (Figure 1). The area is a hilly and gully loess region. The soil type is loessal soil, situated at an average altitude of 850 m, experiencing cold and dry winters and hot summers accompanied by concentrated rainfall. The annual average precipitation stands at 500 mm, with uneven spatial and temporal distribution throughout the year. The rainfall is mainly concentrated from July to September, featuring thunderstorms with short-term heavy rainfall patterns that align with the temperate continental monsoon climate. The vegetation in the study area mainly comprises *Zizyphus jujube* Mill, *Malus pumila* Mill, and *Ziziphus jujuba* Mill. *var. spinosa* [31].

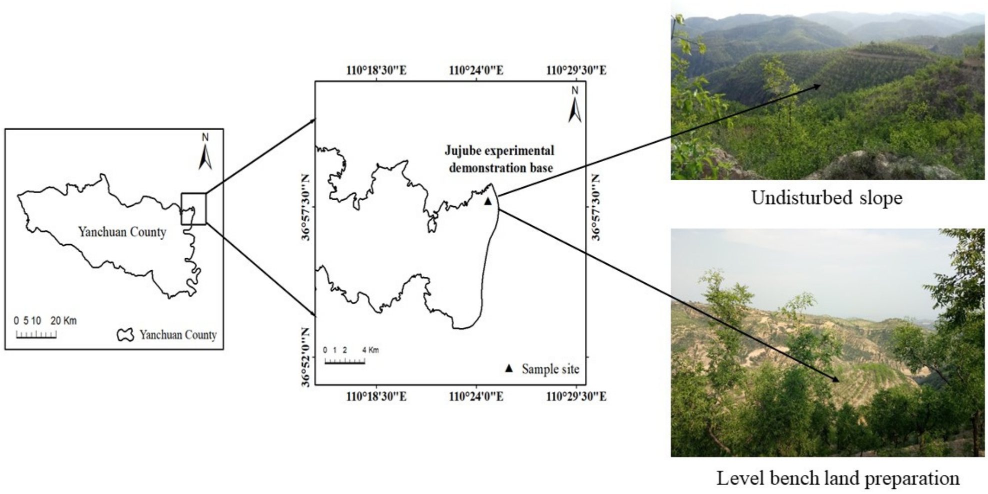

Figure 1. Location of the sampling sites.

2.2. Plot Design and Soil Sampling

By utilizing the space substitution method instead of the conventional time substitution method [32], the sampling quadrats were selected based on the principles of representativeness and typicality. Through preliminary research and fieldwork, the group selected mountain jujube forests and apple forests which were abandoned for the same number of years; a grassland abandoned for the same number of years was selected as the control. A total of six standard sample plots were set (jujube tree (level bench), jujube tree (undisturbed slope), apple tree (level bench), apple tree (undisturbed slope), grassland (level bench), grassland (undisturbed slope) [31]. To avoid any impact on the sampling of rainfall, no precipitation occurred seven days before sampling. In each sample plot, 3 soil profiles (1 m deep) were excavated, and soil samples were collected by the ring knife method with a sampling interval of 20 cm. The soil samples were collected and naturally air-dried in the laboratory for the determination of physical and chemical properties. Detailed information about the sample plots can be found in Table 1.

Table 1. Information on the sample plot.

Sample Number	Plot Type	Soil Type	Altitude (m)	Slope Gradient (°)	Vegetation Coverage (%)	Land Preparation Method	Tending Method
1	JL	Loessal soil	836	0	40	Level bench	Rainfed/no fertilization
2	JU	Loessal soil	860	25	43	Undisturbed slope	Rainfed/no fertilization
3	AL	Loessal soil	900	0	50	Level bench	Rainfed/no fertilization
4	AU	Loessal soil	903	28	52	Undisturbed slope	Rainfed/no fertilization
5	GL	Loessal soil	905	0	82	Level bench	Rainfed/no fertilization
6	GU	Loessal soil	904	30	80	Undisturbed slope	Rainfed/no fertilization

Note: JL, JU, AL, AU, GL, and GU represent the Jujube tree (Level bench), Jujube tree (Undisturbed slope), Apple tree (Level bench), Apple tree (Undisturbed slope), Grassland (Level bench), Grassland (Undisturbed slope).

2.3. Measurement of Indicators

Soil moisture content (SMC) was measured using the drying method, and soil bulk density (BD), total capillary porosity (TCP), saturated water content (SWC), and capillary water-holding capacity (CWHC) were measured using the ring knife immersion method [33]. Clay, silt, and sand were determined using a laser particle size analyzer (soil particle size classification was based on the American soil texture grading standard) [34]. Soil pH and electrical conductivity (EC) were assessed on the pHS-320 high precision intelligent acidity meter and DDS-608 multifunctional conductivity meter, respectively. Available nitrogen (AN), available potassium (AK), and available phosphorus (AP) were determined by alkaline hydrolysis diffusion method, ammonium acetate extraction flame photometric method, and 0.5 mol/L sodium bicarbonate method, respectively, and soil organic matter by the potassium dichromate volumetric method–dilute heat method [35].

2.4. Soil Index Evaluation Methods

Principal component analysis (PCA) was used to reduce the dimensionality and group 17 physicochemical factors. Finally, the soil indicators that had significant effects on soil quality were selected as the minimum data set for soil quality evaluation [36]. The main calculation process included: PCA was used to calculate the norm value grouping and weight calculation of the 17 physicochemical factors; based on the positive or negative correlation between the soil indicator values and soil quality evaluation, the membership function was used for calculation [37]; according to the membership degree and weight values of each soil evaluation index for different vegetation types, the soil quality index for different vegetation types was obtained by multiplying and accumulating the two values. A higher soil quality index indicated a better soil quality restoration effect for the vegetation.

The soil quality evaluation indicator (SQI) was calculated using the weighted evaluation method [38].

$$SQI = \sum_{i=1}^{n} R_i \times F(x_i)$$

where SQI is the soil quality evaluation indicator, R_i is the weighted value of each indicator, n is the number of evaluation indicators, and $F(x_i)$ is the membership value of each indicator.

2.5. Statistical Analysis

The data were processed and analyzed using Excel 2016 and SPSS 22.0, including one-way ANOVA and principal component analysis. One-way ANOVA was used to analyze the differences between various indicators under different vegetation types and different land preparation methods. Principal component analysis was used for grouping various indicators. Origin 2021, Amos 24.0, and ArcMap 10.2 were used for correlation analysis, structural equation modeling (SEM), and sample mapping.

3. Results

3.1. Statistical Differences between Soil Quality Evaluation Indicators under Different Vegetation Types and Different Land Preparation Methods

From Table 2, except for the CWHC, NWC, clay, silt, and sand, the differences between the soil physical indicators of the different vegetation types were not significant ($p > 0.05$) (Table 2). The specific differences between the vegetation types in the soil physical indicators were manifested as jujube trees > apple trees > grassland. It was comprehensively found that the soil physical indicators of the economic forest land were higher, especially in terms of the soil water-retention capacity and physical structure. In terms of the soil chemical properties, there were significant differences in the SOC, TP, and EC among the different vegetation types ($p < 0.05$), whereas other chemical indicators were not significantly different ($p > 0.05$) (Table 2). The SOC and TP contents of grassland were lower than those of jujube and apple trees, whereas the EC was the highest. The combined soil chemical indicators showed that the economic forest had a higher capacity to provide quick-acting nutrients to the vegetation. Comparing different land preparation methods, except for the NWC and sand, there were no significant differences in other physical indicators under different land preparation methods. In terms of the soil chemical indicators, there were significant differences ($p < 0.05$) in the TP and SOC between different land preparation methods, while other chemical indicators were not significant. Overall, the soil physical and chemical indicators under different soil preparation methods showed level bench land preparation > undisturbed slope.

Table 2. Statistical differences between soil quality evaluation indicators under different vegetation types and different land preparation methods.

Soil Indicator	Jujube Tree		Apple Tree		Grassland	
	Level Bench	**Undisturbed Slope**	**Level Bench**	**Undisturbed Slope**	**Level Bench**	**Undisturbed Slope**
BD	1.2 ± 0.09 Aa	1.21 ± 0.08 Aa	1.16 ± 0.07 Aa	1.21 ± 0.04 Aa	1.16 ± 0.04 Aa	1.19 ± 0.04 Aa
SWC	39.57 ± 3.56 Aa	39.57 ± 1.56 Aa	40.35 ± 1.58 Aa	39.19 ± 1.34 Aa	39.6 ± 0.99 Aa	40.41 ± 1.9 Aa
CWHC	33.66 ± 1.1 Bb	33.59 ± 1.52 Bb	35.64 ± 1.42 Aa	33.8 ± 0.93 ABab	34.06 ± 1.4 ABab	34.91 ± 0.26 ABab
TCP	45.9 ± 1.63 Aa	46.98 ± 0.5 Aa	46.87 ± 1.61 Aa	46.83 ± 0.8 Aa	46.01 ± 1.82 Aa	46.5 ± 1.14 Aa
pH	8.46 ± 0.01 Aa	8.46 ± 0.03 Aa	8.46 ± 0.06 Aa	8.49 ± 0.07 Aa	8.51 ± 0.01 Aa	8.47 ± 0.1 Aa
EC	72.56 ± 8.36 Bb	69.2 ± 3.22 Bb	73.48 ± 1.18 Ab	74.69 ± 3.42 Bb	92.06 ± 16.44 Aa	73.64 ± 2.64 Bb
AN	0.13 ± 0.06 Aa	0.1 ± 0.04 Aa	0.15 ± 0.04 Aa	0.13 ± 0.02 Aa	0.16 ± 0.05 Aa	0.13 ± 0.1 Aa
AP	30.44 ± 8.11 Aa	27.1 ± 11.84 Aa	19.5 ± 1.31 Aa	20.28 ± 16.24 Aa	14.29 ± 8.73 Aa	15.5 ± 14.23 Aa
AK	28.7 ± 12.16 Aa	22.08 ± 12.08 Aa	26.68 ± 11.12 Aa	23.36 ± 10.48 Aa	25.62 ± 6.48 Aa	21.56 ± 11.91 Aa
SOC	7.36 ± 0.81 Aa	7.27 ± 0.84 Aa	4.08 ± 1.27 Ab	3.21 ± 1.41 BCbc	2.56 ± 1.04 BCbc	2.39 ± 0.54 Cc
NWC	12.25 ± 1.08 Aa	11.94 ± 1.5 aBb	10.58 ± 0.86 BCbc	10.16 ± 1.21 Cc	8.37 ± 0.86 Dd	5.84 ± 0.25 Ee
NCP	6.06 ± 2.61 Aa	6.3 ± 1.37 Aa	5.35 ± 1.55 Aa	5.96 ± 1.15 Aa	6.41 ± 1.1 Aa	6.35 ± 1.71 Aa
CP	39.84 ± 1.46 Aa	40.68 ± 1.47 Aa	41.48 ± 3.02 Aa	40.91 ± 1.2 Aa	39.6 ± 2.33 Aa	40.15 ± 0.61 Aa
TP	543.88 ± 21.21 ABab	404.18 ± 29.37 Cc	523.24 ± 32.19 ABab	562.33 ± 76.92 Aa	510.16 ± 112.13 ABab	451.9 ± 22.26 BCbc
Clay	4.13 ± 0.37 CDcd	4.69 ± 0.09 ABab	4.42 ± 0.32 BCbc	4.29 ± 0.14 CDcd	3.94 ± 0.22 Dd	4.79 ± 0.14 Aa
Silt	74.29 ± 1.11 Bb	79.12 ± 1.26 Aa	75.82 ± 0.78 Bb	75.08 ± 2.04 Bb	75.65 ± 0.93 Bb	76.21 ± 0.94 Bb
Sand	21.57 ± 1.35 Aa	16.18 ± 1.2 Cc	19.76 ± 1.1 Bb	16.03 ± 0.98 Cc	20.4 ± 0.96 ABab	18.99 ± 0.91 Bb

Note: The single factor variance Duncan method was used to analyze the differences between the same indicator among different vegetation types and different soil preparation methods ($p < 0.05$). Lowercase letters represent different vegetation types, uppercase letters represent different soil preparation methods, and different letters indicate significant differences. Bulk density: BD; saturated water content: SWC; capillary water-holding capacity: CWHC; total capillary porosity: TCP; electrical conductivity: EC; available nitrogen: AN; available phosphorus: AP; available potassium: AK; total phosphorus: TP; soil organic carbon: SOC; natural water content: NWC; non-capillary porosity: NCP; capillary porosity: CP.

3.2. Evaluation of Soil Quality

3.2.1. Characteristics of Soil Indicator Components Based on the Minimum Data Set

To reduce the number of indicators and minimize data redundancy caused by the high correlation between evaluation indicators, principal component analysis (PCA) was performed on 17 indicators. The results are shown in Table 3. In total, 5 principal components with eigenvalues greater than 1 were obtained, and the cumulative explanatory power was 80.003%, indicating that the explanatory power of the 5 principal components was strong. After screening all indicators, those with load values of ≥0.5 were classified as Group 1. If the same indicator appeared in two principal components at the same time, it was merged into the group with a lower correlation according to the correlation (Table 3). Then, the correlation analysis was performed on the indicators in each group. If two indicators in the same group had a significant correlation, the indicator with a higher norm value was retained. Finally, the minimum data set of the soil quality evaluation indicators in this study was determined to be the BD, SWC, SOC, AN, silt, and TCP. The SOC and SWC have relatively large weights and are crucial for the evaluation of the soil quality.

Table 3. Principal component analysis of soil quality indicators.

Soil Indicator	PC1	PC2	PC3	PC4	PC5	Classing	Norm	Communality	Weight
BD	−0.923	−0.190	0.042	0.074	−0.121	1	1.715	0.823	0.181
SWC	0.894	−0.005	0.011	0.361	0.106	1	1.660	0.919	0.202
NCP	0.870	−0.135	0.196	−0.085	0.258	1	1.616		
Silt	−0.083	−0.896	−0.038	−0.004	−0.250	2	1.545	0.590	0.130
Sand	0.115	0.773	0.030	−0.027	0.021	2	1.333		
Clay	0.210	−0.769	−0.020	0.108	0.318	2	1.326		
TP	0.032	0.716	0.087	−0.267	0.175	2	1.235		
SOC	0.055	−0.100	0.927	−0.016	0.115	3	1.529	0.929	0.205
NWC	−0.070	0.042	0.872	0.053	0.110	3	1.438		
AP	0.180	0.252	0.782	−0.079	0.114	3	1.289		
TCP	0.125	−0.210	0.031	0.844	0.039	4	1.284	0.702	0.155
CWHC	0.478	0.145	−0.371	0.684	−0.125	4	1.040		
CP	−0.663	−0.033	−0.148	0.676	−0.194	4	1.028		
EC	0.301	0.377	−0.293	−0.610	−0.081	4	0.928		
AN	0.228	0.189	−0.057	−0.214	0.826	5	1.209	0.576	0.127
AK	0.334	0.276	0.372	−0.017	0.737	5	1.079		
pH	−0.029	0.128	−0.222	−0.143	−0.730	5	1.069		
Eigenvalue variance (%)	3.452	2.972	2.719	2.313	2.145				
contribution rate (%)	20.306	17.483	15.993	13.606	12.615				
Accumulative contribution rate (%)	20.306	37.790	53.782	67.388	80.003				

3.2.2. Soil Quality Assessment Based on a Minimum Data Set

By using the minimum data set to calculate the soil quality index of different vegetation types under different land preparation methods in the study area (Table 4), it was found that the SQI values of the economic forest land were higher than those of the grassland, specifically manifested as jujube trees > apple trees > grassland. When comparing the different land preparation methods, it was found that the SQI level bench land preparation was higher than those of the undisturbed slope for the same vegetation type, indicating that the level bench land preparation method had a positive effect on improving the soil quality. Moreover, as shown in Figure 2, there was a good linear relationship between the minimum data set and the total data set ($y = 0.75x + 0.124$), with an R^2 value of 0.837. A higher R^2 value indicated a better fitting effect, suggesting that the soil quality index calculated based on the MDS method could be used for soil quality evaluation in the study area.

Table 4. The soil quality evaluation results of different vegetation types and land preparation methods based on the minimum data set.

Vegetation Type	Jujube Tree		Apple Tree		Grassland	
	Level Bench	Undisturbed Slope	Level Bench	Undisturbed Slope	Level Bench	Undisturbed Slope
SQI-MDS	0.63	0.59	0.59	0.53	0.54	0.52

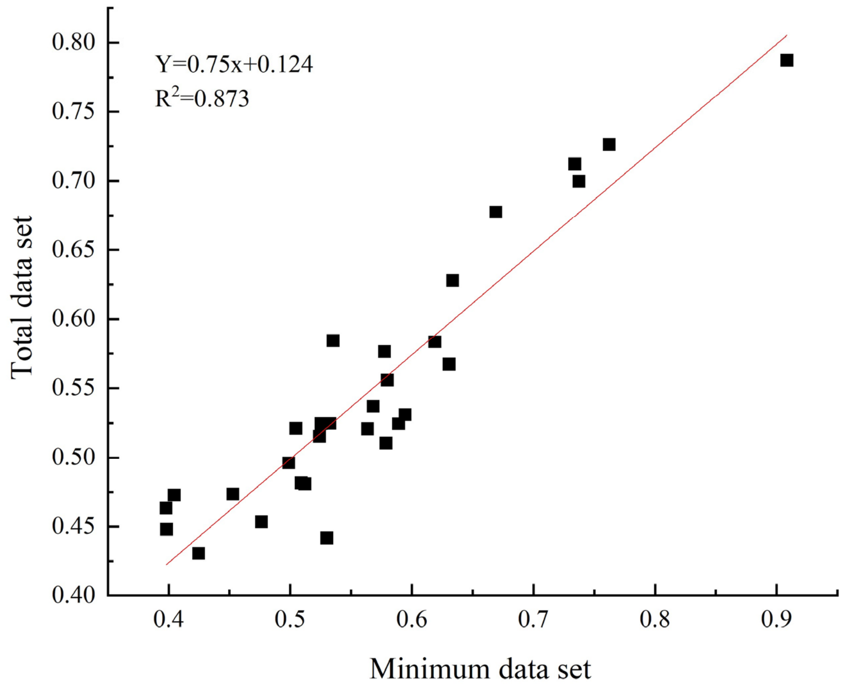

Figure 2. Linear fitting relationship between the minimum data set and the total.

3.3. Effects of Dominant Factors on Soil Quality

The direct and indirect effects of the dominant factors on the SQI under different vegetation types and land preparation methods were analyzed using a structural equation model. The results are shown in Figure 3. Among the different vegetation types, the SWC and SOC had a greater impact on the SQI of the forest lands and had a direct positive impact. The AP has a direct negative impact on the SQI of the apple forest land. The soil texture has a significant influence on the grassland and has a direct positive impact. The soil nutrient indicators have little effect on the grassland SQI. The AN had a certain influence on the SQI of the different vegetation types, but its influence intensity was low. Porosity influences the SQI of different vegetation types. By comparing different soil preparation methods, it was found that chemical indicators were the main factors affecting the SQI of different vegetation types in the level bench land preparation.

The Inclusion of soil organic carbon and available nutrients had a significant impact on the SQI of the level bench forest land, whereas clay and the pH had a significant impact on the SQI of the level bench grassland. The physical indicators have a significant impact on the SQI of different vegetation types on an undisturbed slope. The CP and SWC had a significant influence on the SQI of the forest land on the undisturbed slope, and sand had a significant influence on the SQI of the grassland. The SOC and CP had a significant influence on the jujube trees and grassland and had a greater significant influence on the jujube SQI. Soil water and carbon had a direct positive impact on the SQI of the economic forest land on the undisturbed slope.

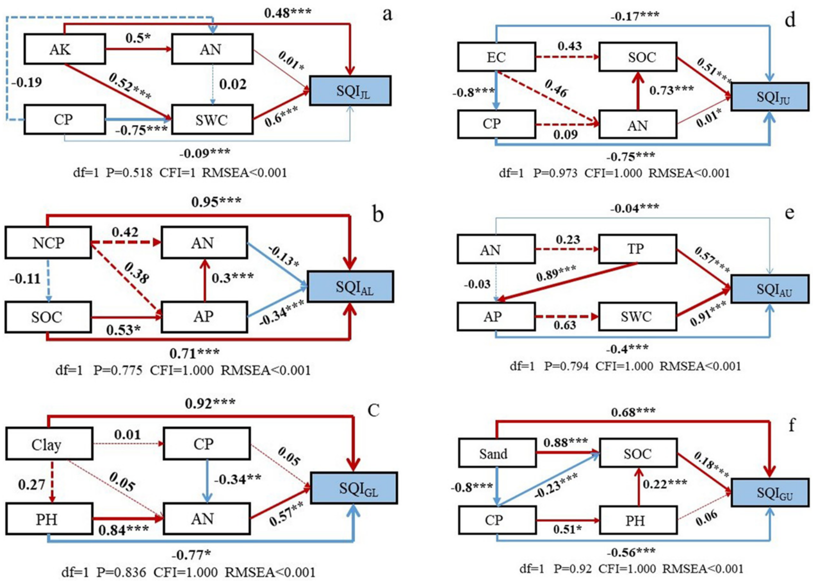

Figure 3. Effects of different main control factors on the SQI. (**a**–**c**) represent the level bench of jujube, apple tree, and grassland, respectively; (**d**–**f**) represent the undisturbed slopes of jujube trees, apple trees, and grassland, respectively. The red arrow indicates a significant positive impact, the blue arrow indicates a significant negative impact, the dotted arrow indicates an insignificant impact, and the thickness indicates the size of the path coefficient. *** represents a significant correlation at the 0.001 level, ** represents a significant correlation at the 0.01 level, and * represents a significant correlation at the 0.05 level.

4. Discussion

4.1. Difference Analysis of Soil's Physical and Chemical Properties of Different Vegetation Types

Vegetation can affect the transformation of the soil's physical structure and the circulation and distribution of nutrient resources in the ecosystem by changing the quality and quantity of litter and the abiotic environment through its physiological activities [39]. This study shows that compared with grassland, the economic forest has more advantages in improving soil's physical and chemical properties. This may be due to the large amount of litter and humus on the surface of forest land, the high content of organic matter, the improvement in the soil's structure, and the increase in the soil's aggregate stability [40]. Simultaneously, owing to the improvement in plant roots in the soil [41] and the interference of human activities on the economic forest land, the physical and chemical properties of the soil are improved. The grassland surface litter is less and relatively bare. The climate is dry, and soil moisture evaporation is strong in the study area, resulting in a low soil moisture content in the grassland. The soil environment for vegetation growth is poor, and litter is easily photolyzed under strong light, which ultimately leads to difficulties in the formation and accumulation of grassland nutrients [41]. Some studies have also shown that land preparation methods have an important impact on changes in the physical and chemical properties of the soil [42,43]. The soil environment and conditions can be improved by transforming the undisturbed slope in other ways to improve the soil's texture, physical and chemical properties, and nutrient conditions [44,45].

The results of this study indicated that the level bench has a stronger impact on the physical and chemical properties of the soil, which may be due to the influence of the slope on runoff, whereas the level bench land preparation changed the slope of the original vegetation growth, reduced the runoff speed, increased the effective water storage of plants, and enhanced the occurrence of infiltration [46]. Simultaneously, the soil preparation of level benches has a strong ability to retain runoff and litter, which strengthens the humification, enriches the nutrient elements in the surface layer, and increases the soil's nutrient content [44,47,48]. This effectively improves the properties of the soil. The undisturbed slope condition has weak interception effects on the soil's moisture and nutrients, which is not conducive to improving the soil's properties [49].

4.2. Evaluation of Soil Quality Based on the Minimum Data Set

Many domestic and foreign scholars [38,50–52] often incorporate organic matter, soil bulk density, alkaline nitrogen, porosity, and other indicators into the minimum data set when studying the quality status of soil to evaluate soil quality. In this study, the SOC, SWC, BD, TCP, silt, and AN were selected as the soil quality evaluation indicators, which is consistent with most domestic and foreign research results. This study also showed that the SOC and SWC are important indicators of soil quality, similar to previous studies [26,53]. Studies have shown that compared with TDS, the MDS method is widely used, because the MDS method can improve work efficiency, and reduce time and cost [54–56]. This study indicates that the soil quality index calculated based on the MDS method applies to the study area. Therefore, the MDS method can replace TDS for evaluating soil quality in the study area [37].

This study showed that the economic forest land is conducive to soil restoration and possesses a higher soil quality in the study area, which may be due to the strong human disturbance of the economic forest land, such as regular weeding, loosening of soil, and fertilization. Compared with apple trees, jujube trees have more developed roots [57], and different vegetation types have different microclimates on their underlying surfaces. The accumulation of litter and rhizosphere sediments affects the activity of soil microorganisms, changes the rate of carbon conversion, and affects soil quality [58,59]. The results of this study demonstrate that changing the land preparation methods is beneficial for improving soil quality. This is because the level of terrace land preparation plays an important role in reducing runoff, reducing soil erosion, increasing soil nutrient flux, improving soil fertility, and increasing crop yield [60]. However, the lack of reasonable maintenance and natural and man-made interactions will destroy the structure and strength of land preparation, resulting in the complete failure of the land preparation method [31,45].

Scientific management is the key to sustainable development. Relevant studies have shown that a reasonable combination of land preparation methods and vegetation types can achieve sustainable land restoration and create the greatest socio-ecological-economic benefits [61]. The excessive use of sloping land leads to soil carbon loss and stoichiometric imbalance, resulting in soil degradation and reduced ecosystem services [62].

4.3. Effects of Dominant Factors on Soil Quality

Factors affecting soil quality differ significantly under different environmental conditions. This study demonstrates that the dominant factors that affect the SQI among different vegetation types show differences. According to the correlation between the indicator, SQI, and the path coefficient, SWC, and SOC were the main factors affecting the SQI in the economic forest land, mainly because the soil's water and carbon play an important role in vegetation growth. Soil organic carbon controls many soil physical, chemical, and biological processes that affect plant growth and sustainability [63] and plays a key role in soil function. At the same time, studies have shown that the SWC is an important water-holding indicator that affects plant growth and ecological processes [26,64]. During the growth of vegetation, changes in soil moisture directly affect the growth of plants, and owing to differences in vegetation types and coverage, it affects evaporation, seepage, soil structure, and soil water-holding capacity [65]. Simultaneously, the AN affected almost all vegetation types in this study. As an important nutrient indicator of soil, it has an important impact on soil quality evaluation [66]. This study also showed that the CP plays an important role in the SQI of different vegetation types, and related studies have shown that porosity is related to soil water and air movement and the supply of vegetation nutrients [67]. When the soil porosity increases, the better the soil water retention [68]. In summary, when improving the soil quality of the economic forest land in the future research area, addressing water and carbon issues is crucial, and nutrient accumulation cannot be ignored.

This study shows that the SWC and CP have a significant impact on the SQI of different vegetation types under the undisturbed slope, and the SOC and AN have a significant impact on the SQI of different vegetation types under the level bench land preparation. This is because the undisturbed slope erosion is serious and the water-retention capacity is poor [69]. Effectively holding water is an important factor in improving soil quality and promoting vegetation growth. Level bench land preparation can effectively improve the ability of water collection and retention to a certain extent [70]. However, due to natural and anthropogenic factors, soil quality is reduced. Without reasonable maintenance, the soil will be damaged in the event of heavy rainfall, leading to nutrient loss and soil quality reduction. The accumulation of soil organic carbon, N, P, K, and other nutrient elements mainly depends on the combination of vegetation type, community structure, and soil preparation method [71], which is consistent with the results of this study. Therefore, water conservation and soil consolidation are important for improving the soil quality of economic forest lands on the undisturbed slope in the future. Relevant studies have shown that the use of agroforestry on sloping land and inter-row intercropping [72] plays a significant role in solving such problems. When land preparation methods change, the impact of scientific management methods and planting patterns on nutrients should be considered.

5. Conclusions

This study showed that the physicochemical properties of soil evaluation indicators were different under different vegetation types and land preparation methods. The MDS selection based on principal component analysis was correlated with the soil quality evaluation, and the soil quality of the economic forest land was higher in the soil quality assessment under different vegetation types as well as different land preparation methods; it showed that the soil quality of the level bench land preparation was higher than that of the undisturbed slope under different land preparation methods, which had a positive effect on the improvement in the soil's quality. Furthermore, using structural equation modeling, it was concluded that the SOC, SWC, AN, and CP were the dominant factors affecting the soil quality of different vegetation types in the study area, among which the SWC and CP had a greater influence on the soil quality of the intact slopes, and the SOC and CP had a greater influence on the soil quality of the level bench land preparation. Therefore, the current maintenance, as well as improvement in soil quality, needs to pay attention to the water–carbon status as well as the nutrient accumulation status.

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