

Characteristics of soil organic carbon distribution in different economic forests in Gangu County, Gansu Province, China

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Abstract

SOC (Soil organic carbon) is an important indicator of soil nutrients and is essential for maintaining ecosystem functions and preventing land degradation. In this study, five types of economic forest plots were selected as sample plots (*Malus pumila*, *Juglans regia*, *Zanthoxylum bungeanum*, *Prunus persica*, and *Prunus armeniaca*) in Gangu County, Gansu Province, and wasteland was used as a control to investigate the changes of soil organic carbon content in 0-100 cm of different economic forests in Gangu County. The results showed that the soil organic carbon content of different economic forests in Gangu County ranged from 9.17 ± 0.15 – 17.20 ± 0.13 g/kg, and the soil organic carbon content at 0-100 cm depth ranged from high to low: apple (*Malus pumila*), pepper (*Zanthoxylum bungeanum*), walnut (*Juglans regia*), apricot (*Prunus armeniaca*), peach (*Prunus persica*) and wasteland. The SOC content of the five forest types and the wasteland showed apparent surface aggregation, with the highest SOC content of 17.20 g/kg for *Malus pumila* and the lowest SOC content of 12.65 g/kg for the wasteland in the 0–10 cm surface layer; in the 80–100 cm deep layer, the highest SOC content of 14.90 g/kg for *Juglans regia* and the lowest SOC content of 9.17 g/kg for the wasteland. SWC (Soil water content, SWC) and S-UE were the most influential factors on the SOC content of *Juglans regia*; S-CAT (Soil catalase, S-CAT) was the most influential factor on the SOC content of *Malus pumila*; SBD (Soil bulk density, SBD) was the most influential factor on the SOC content of *Prunus armeniaca*, *Prunus persica*, and *Zanthoxylum bungeanum*; the SOC content of the control wasteland was more influenced by S-CAT and soil fungi. The number of S-CAT and soil fungi more influenced the SOC content of the control wasteland. Overall, the mean SOC content of *Malus pumila* and *Prunus persica* in 0-100 cm soils is relatively high among the five economic forest species. Therefore, *Malus pumila* is the preferred choice for economic forest planting in Gangu County. In the future economic development and ecological restoration practice of Gangu County, it is recommended to plant a mixed forest planting pattern of *Malus pumila* and *Zanthoxylum bungeanum*, which is conducive to improving the potential carbon sink function of economic forests in the region.

Introduction

The soil carbon pool is the largest reservoir in terrestrial ecosystems, about 3.3 times larger than the atmospheric carbon pool and 4.5 times larger than the biogenic carbon pool. Among these, soil organic carbon pools, an important indicator of soil fertility and one of the significant carbon pools in terrestrial ecosystems, amount to 1220–1576 Pg above 1 m globally (Yang et al., 2015). Soil organic carbon is essential for providing soil nutrients and reducing erosion (Fu et al., 2009). To cope with climate change and improve fragile habitats, since the late 1970s, China has implemented national projects such as the “Three Norths” afforestation project (1978–2050) and the “Return of Cropland to Forests (Grass)” project (1999–2020) (Zhao et al., 2017; You et al., 2020). Planted forests have increased ecosystem productivity and soil carbon stocks in fragile habitats and have slowed down soil erosion and soil erosion to some extent (Kebede et al., 2018). Assessing different vegetation types’ soil organic carbon (SOC) content contributes to carbon sequestration and ecological improvement (Moriarty et al., 2010).

SOC content varies depending on the type of soil or land use (Paul et al., 2016). Differences in vegetation type also affect SOC content, as plant carbon sequestration varies due to different vegetation productivity. In contrast, the quality and quantity of apoplastic matter vary between vegetation, and the fraction returned to the soil is affected by microbial influences that further affect SOC. Wang et al. (2010) studied the carbon storage capacity of artificial lateral cypress and acacia growing on the Loess Plateau and concluded that the carbon sink capacity of acacia was higher than that of lateral cypress in the same geographical area. Fan et al. (2018) showed that the SOC content of evergreen broad-leaved forests was higher than that of pure fir plantations of the same age. Wan et al. (2019) found that the SOC content of typical vegetation types in the upper reaches of the Qilianshan Shiyang River Basin was alpine meadow > Qinghai spruce > poplar > subalpine shrub. Luo (2019) used a typical vegetation community in a semi-arid loess area as a study object and found that SOC content was highest in small-leaved famous, followed by barren grassland, and smallest in lemongrass.

Gangu County is a central agricultural county in northwest China and one of the base counties of Gansu Province's substantial plateau summer dish "Western Cuisine to East Transfer" (Fu et al., 2020). At this stage, understanding the content level and distribution of SOC in Gangu County has important practical significance for improving soil carbon sequestration potential and guiding agricultural production. At present, relevant research mainly focuses on the change of soil organic carbon content in different land use modes (such as grassland, forest, wetland, etc.) (Akpa et al., 2016; Lal et al., 2018; Liu et al., 2012), but the effect of carbon sequestration and sink enhancement of different economic forest soils, and its influencing factors are still unclear. Therefore, based on the distribution characteristics of SOC (0-100 cm) under different economic forest types (*Malus pumila*, *Juglans regia*, *Zanthoxylum bungeanum*, *Prunus persica*, *Prunus armeniaca*, wasteland), this study explored the difference of SOC of different economic forest vegetation types and its relationship with other environmental factors, providing a scientific basis for the optimal selection, rational management and soil carbon sequestration and sink enhancement of economic fruit forests in Gangu County.

Materials And Methodology

Study Area

Gangu County (34°32'-35°03'N, 105°02'-105°31'E) in Tianshui City, Gansu Province, is located in the southeast of Gansu Province, upstream of the Wei River, and belongs to the semi-arid region of the Loess Plateau. The county has an average altitude of 1972 m and a semi-humid continental monsoon climate, with an average annual temperature of 11.5 °C, including the highest temperature in July, with an average of 25 °C and the lowest temperature in January, with an average of -1 °C. The rainfall is low in spring and high in summer, with an annual rainfall of less than 500 mm (Xiao et al., 2017); the annual sunshine is about 2100 h; the soil in the territory is The DEM (Digital Elevation Model, DEM) is an irregular triangular network derived from contour lines spaced 1 m apart using ArcGIS 10.2 (Fig. 1).

Soil sampling

In October 2020, after a field survey of the economic forest plantation areas in Gangu County, we selected six townships (Anyuan Township, Xiejiawan Township, Xinxing Township, Daxingshan Township, Liufeng Township, and Baijiawan Township) as sampling areas, and these six townships were representative of the entire economic forest plantation situation in Gangu County. In each sampling area, representative *Malus pumila*, *Juglans regia*, *Zanthoxylum bungeanum*, *Prunus persica*, *Prunus armeniaca* were selected as sample plots, and wasteland was used as a control. 42 30 m × 30 m sample plots were randomly laid out to investigate and record the background information of each plot. In each sample plot, three small 10 m × 10 m squares were selected along the diagonal (ends and midpoints), and soil samples were taken in six layers: 0–10 cm, 10–20 cm, 20–40 cm, 40–60 cm, 60–80 cm, and 80–100 cm, avoid fertilizer ditches (pits) and irrigated wet areas, with two replicates in each layer, using a 3.5 cm diameter soil auger to collect soil samples. The coordinates of the sampling points were recorded using the Global Positioning System (GPS).

Laboratory analyses

A soil depth of 100cm is likely to reflect the main root distribution of the forest (Han et al., 2017). Soil samples were taken for a profile depth range of 0–10 cm, 10–20 cm, 20–40 cm, 40–60 cm, 60–80 cm, and 80–100 cm, using a cutting ring whose volume was equivalent to 1×10⁻⁴ m³ (Wu et al., 2016). After labeling, soil samples for bulk density (SBD) and soil water content (SWC) were transported to the laboratory and oven-dried to constant weight at 105°C. Soils were air-dried and stored in a dark place. After removing impurities such as root material, soils were processed using a 2 mm mesh sieve. SOC was determined using a potassium dichromate oxidation ferrous sulfate titration method (Bremner et al., 1972). CEC and pH were analyzed in a 1:5 soil:water extract using a conductivity meter (DDS-307, Leici, China) and a pH meter (PHS-3C, Leici, China), respectively. The soil microorganisms were cultured by the dilution pouring coating plate method (Norman et al., 1939). The activity of soil urease (S-UE) was determined by phenol sodium hypochlorite colorimetry, the activity of soil catalase (S-CAT) was determined by potassium permanganate titration, and the activity of soil sucrase (S-SC) was determined by 3,5-dinitro salicylic acid colorimetry.

Data analysis

Data were analyzed using SPSS 22.0 statistical software (SPSS Inc. Chicago, USA). Linear regression analysis was conducted on the relationship between SOC and soil depth by LSD (least significant difference) test ($p < 0.05$). AMOS21.0 is the structural equation model (SEM) to analyze the path coefficients between variables. The relatedness between SOC and other soil properties (such as SWC, soil pH, and SBD), soil enzyme activities, and soil microbial counts was expressed by correlations. The different impact factors were sorted with the gradient boosting decision tree (GBDT) model according to their effects on the SOC. The GBDT is a machine-learning decision tree model with a high accuracy rate

for various data types. The Origin Pro 9.0 and ChiPlot software were then adopted to visualize the data through appropriate visual and statistical diagnostic plots.

Results

SOC content in different economic forests

Fig. 2 shows that the SOC content of the five economic forest vegetation and wasteland ranged from 9.17 ± 0.15 – 17.20 ± 0.13 g/kg, with *Malus pumila*, *Juglans regia*, *Zanthoxylum bungeanum*, *Prunus persica*, *Prunus armeniaca* and wasteland having a SOC content of 13.14 ± 0.14 – 17.20 ± 0.13 g/kg, 14.90 ± 0.12 – 16.81 ± 0.23 g/kg. In the same soil layer, the SOC content of different economic forest plantations varied. In the top layer of 0–10 cm, the SOC content of *Malus pumila* was the highest at 17.20 g/kg, while the SOC content of wasteland was the lowest at 12.65 g/kg. The SOC content of the same vegetation type varied at different soil depths. The vertical distribution of SOC in the six vegetation types can be well described by a quadratic function (R^2 in the range of 0.713 to 0.921) (Fig. 3).

Changes in SWC, pH, CEC and SBD in different economic forests

Figure 4 shows that the SWC in the study area is between 11.33% and 20.31%. Significant differences ($p < 0.05$) were detected between different vegetation types in SWC in the 0–100 cm soil layer. The SWC of 6 vegetation types decreased with the increase in soil depth. Among the six vegetation types, the SWC in the 0–20 cm soil layer is markedly higher than in other soil layers. The SBD studied is between 0.88–2.20 g/cm³. The SBD varied significantly ($p < 0.05$) concerning vegetation type and soil depth. There was an increasing trend in the SBD with soil depth in all vegetation types. For all vegetation types, the SBD of the 80–100 cm soil layer was significantly higher than that of the other soil layers. The pH of the area studied is 7.95–8.52, and the soil is alkaline. Vegetation type and soil depth significantly affected the pH; the pH value increases with the increase of soil depth. The CEC in the area studied is between 197.60 $\mu\text{s/cm}$ and 273.67 $\mu\text{s/cm}$. The linear trend of CEC change with soil depth is not apparent, the maximum value appears in the 60–80 cm soil layer of *Zanthoxylum bungeanum*, and the minimum value appears in the 10–20 cm soil layer of *Juglans regia*.

Changes in microbial taxa and enzymatic activity in soils of different economic forests

Soil bacteria, actinomycetes, and fungi are the main soil microbial groups and play an essential role in soil organic matter's decomposition, mineralization, and nutrient cycling. As can be seen from Fig. 5: The variation in the total number of microorganisms in the different vegetation types is: *Juglans regia* > *Malus pumila* > *Zanthoxylum bungeanum* > *Prunus armeniaca* > *Prunus persica* > wasteland. For example, in the 0–10 cm soil layer, the bacterial count of walnuts was 18.90×10^6 cfu/g, while that of barren land

was only 1.46×10^6 cfu/g. Among the same vegetation types, the number of soil microorganisms was the highest for bacteria, and the distribution of actinomycetes in the soil was second only to that of bacteria. The distribution of soil microorganisms was second only to bacteria, and the number of fungi was the lowest. Regarding the vertical distribution of soil microorganisms, soil bacteria, actinomycetes, and fungi show a decreasing trend as the soil layer deepens in different vegetation types. All microorganisms are mainly distributed in the 0–20 cm soil layer.

Soil enzyme activities were found to be the highest in the 0–10 cm surface layer for *Juglans regia* (0.93 mg/g) and peroxidase (11.47 mg/g) and the highest for *Malus pumila* (16.8 mg/g), and the lowest for wastelands (16.8 mg/g). Soil urease, peroxidase, and sucrose enzyme activities of the five economic forest vegetation species and the wasteland decreased as the soil profile deepened. Three soil enzymes were more active in the 0–20 cm soil layer, declining rapidly below the 60 cm soil layer, then leveling off.

Correlation analysis of soil organic carbon content of different economic forests with other environmental factors

Figure 7 shows a positive correlation between soil organic carbon content, soil enzyme activity, and soil microbial population in all five economic forest species. The correlation coefficient between SOC content and S-UE for *Juglans regia* was 0.865 ($p < 0.01$), and that between SOC content and S-SC for *Zanthoxylum bungeanum* was 0.853 ($p < 0.01$), both of which were highly statistically significant. The SOC content of *Malus pumila* showed a significant correlation with the number of bacteria; the SOC content of *Prunus armeniaca* showed a significant correlation with the number of fungi. Soil conductivity of the five economic forest vegetation species showed a weak positive correlation with SOC content. The correlation between SWC and SOC content was positive for all five economic forest vegetation species, with the correlation between SWC and SOC content of *Prunus persica* and *Prunus armeniaca* being higher at 0.899 and 0.934, respectively ($p < 0.05$). There was also a significant negative correlation between soil capacity and SOC content. As soil capacity increased, the SOC content of the economic forest vegetation tended to decrease, with the SOC content of the wasteland being most affected by soil capacity. The soils in the study area are predominantly primary and calcareous, with the pH of the calcareous soils ranging from 8.18 to 8.53. The SOC content of the economic forest vegetation decreases as the pH increases.

GBDT analysis

Figure 8 shows the ranking of the importance (percentage) of the gradient-boosting decision tree (GBDT) for each environmental variable. The most crucial factor affecting SOC content in the *Malus pumila* was S-CAT, with importance of 33.70%; SWC and S-UE had an importance of 27.30% and 26.20%, respectively; SBD was the most critical factor affecting SOC content in *Prunus armeniaca*, *Prunus persica*, and *Zanthoxylum bungeanum*, with the importance of 35.50%, 25.80%, and 38.70% respectively; S-CAT and soil fungi population had the most significant contribution to SOC content in the wasteland, with a contributed most significantly to the SOC content of the wasteland, with 20.60% and 18.40% respectively.

Structural equation modelling

SOC balance is a complex process; structural equation modeling (SEM) can describe this complex relationship very well. Figure 9 shows that CEC, SBD, SWC, pH, soil microbial population, and soil enzyme activity directly influence SOC content in the study area. CEC, SBD, and pH indirectly affect SOC content by influencing soil microbial population and soil enzyme activity, respectively.

Discussion

Effect of vegetation type on SOC content

Different vegetation types differ in their growth characteristics and root secretions, resulting in differences in the amount of surface zooplankton and root microbial activity, which can lead to changes in SOC input and output (Nie et al., 2014). Gloria et al. (2007) showed that vegetation mainly uses its return of zooplankton, root secretions, and soil microbial decomposition capacity to influence SOC and storage. The results of this study showed that the highest SOC content was found in the 0-10 cm surface soil of *Malus pumila*, followed by *Zanthoxylum bungeanum*, which was richer in SOC, while the SOC content of wasteland was the lowest (Fig.2). This may be because *Malus pumila* in Gangu County have been planted for a relatively long time, that the undergrowth of *Malus pumila* is rich in biodiversity such as grass cover and soil fauna, that the surface layer of dead litter is thick, that humus is also thick, and that the soil microbial population is rich in soil microbial taxa and root secretions, and therefore SOC is richer. As there are relatively few anthropogenic activities under the *Zanthoxylum bungeanum*, the damage to its surface is relatively small, which is conducive to the preservation and input of plant residues. A study by Xu (2022) et al. proved that the apoplastic material produced by trees could improve the carbon sequestration capacity of the soil. At the same time, the canopy structure of trees can play an influential role in shading, reducing the soil temperature in the understory and slowing down the rate of organic carbon mineralization, which directly affects the exchange of material and energy between the plant community and the environment (Nick et al., 2000). The five economic forest vegetation species studied in this paper are deciduous trees whose apoplastic material provides a source of surface SOC, and the canopy provides a boundary to maintain microclimatic zones that influence soil carbon release (Saha et al., 2022). In contrast, the vegetation cover of the heathland is mostly grassland, which has a relatively shallow root system and low biomass and zooplankton return. In this study, the SOC content of the wasteland was lower than that of the economic fruit tree forest in all soil layers from 0-10 cm, 10-20 cm, 20-40 cm, 40-60 cm, 60-80 cm, and 80-100 cm.

Vertical distribution of soil organic carbon with soil depth

The generation of phenol concentration of SOC content mainly depends on factors such as the condition of surface vegetation, the amount and mode of entry of organic matter into the soil, and the soil leaching condition (Yu et al., 2020). The SOC content of all five types of economic forest vegetation and wasteland in Gangu County decreased with the deepening of the soil layer, and the SOC content under each cover

type showed a negative correlation with soil depth (Fig. 3). In the 0-10 cm topsoil, different plants produce different amounts and quality of apoplastic material, which increases the input of exogenous organic matter. The decaying plant residues in the soil effectively change the physicochemical properties of the soil, affecting the decomposition and transformation of microorganisms in the soil through soil respiration and other means and helping the soil to accumulate organic carbon. The decomposition products of vegetation withers and arthropod exoskeletons continue to migrate downwards from the surface layer under the action of soil leaching. However, with the increase in soil depth, the 60-80 cm and 80-100 cm subsoil layers are gradually weakened by the action of organic matter and microorganisms in the surface layer.

Vegetation characteristics determine root characteristics that influence soil nutrient inputs (Wang et al., 2015), differences in rooting depth of different tree species also influence the vertical distribution of SOC in the soil profile (Laganière et al., 2017), and deeper plant roots reduce the loss of SOC due to rainfall (Guo et al., 2020). Plant root secretions also influence the distribution pattern of SOC (Li et al., 2021). *Juglans regia* is a deep-rooted tree species, and in terms of vertical distribution, the 0-70 cm soil layer is the central area of vertical root distribution, with root biomass accounting for 85.45% of the total vertical distribution (Song et al., 2018). The root system of *Malus pumila* can reach a depth of 80-100 cm in the soil layer, and the root mass in the 0-60 cm soil layer accounts for about 80 % of the total root system (Hao et al., 1998). *Zanthoxylum bungeanum* is a shallow-rooted tree with a shallow vertical root system and a wide horizontal distribution. *Prunus persica* is a shallow-rooted fruit tree with absorbing roots usually within 40 cm of the soil layer, with 10-30 cm being the zone of vigorous growth and development. This is consistent with the ranking of the size of the soil organic carbon content of each tree species in this study, with *Juglans regia* and *Malus pumila* having higher SOC content in the deeper soil layers of 60-80 cm and 80-100cm, while the SOC content of *Zanthoxylum bungeanum* decreases significantly from the 0-60 cm soil layer, and the SOC of *Prunus persica* has the lowest organic carbon content in the 60-80 cm and 80-100 cm soils.

Main drivers of change in soil organic carbon in different economic forests

The synergistic effects of plant communities and soil physicochemical properties significantly impact SOC, mainly sourced from above-ground zooplankton, soil microorganisms, roots, and their secretions, and it is also influenced by soil moisture and pH (Lei et al., 2014). In this study, it was found that the soil physicochemical properties of different economic forest types showed different trends with increasing soil depth (Fig. 4). The number of soil microorganisms and soil enzyme activities showed a gradual decrease with deeper soil depth (Fig. 5, Fig. 6). It has been suggested that bacteria make up the most significant proportion of the soil flora and play an essential role in the degradation and decay of plant and animal residues (Cramer et al., 2001). SOC content was positively correlated with SWC, soil enzyme activity, and soil microbial population in all five economic forests ($p < 0.05$), while soil electrical conductivity showed a weak positive correlation with SOC content ($p > 0.05$). The correlation between SOC content and soil capacitance was also significant ($p < 0.05$): as soil capacitance increased, the SOC content of each land use type tended to decrease (Fig. 7). This may be because soil microorganisms, as

active factors in the soil, are involved in various soil biochemical processes such as organic matter decomposition, nutrient conversion, and cycling (Powlson et al., 1987) and are the main drivers of soil mineral element cycling and turnover (Fu et al., 2009); soil moisture affects ecosystem productivity and microbial activity and is a crucial factor influencing SOC decomposition. The higher the SWC, the poorer the soil aeration, which in turn decreases the number of aerobic bacteria and weakens the mineralization process of SOC, which in turn makes the input process of organic matter in the soil much greater than the output process and increases the SOC content under the long-term accumulation effect (Qiao et al., 2019). The higher the SBD, the lower the soil porosity, which is an essential indicator of aeration (Ge et al., 2020), and the poorer the soil permeability and aeration, the less conducive to microbial survival and plant root growth, which in turn affects the SOC content (Gao et al., 2016).

In this paper, SWC and S-UE are the distinguishing factors that have a more significant influence on the SOC content of *Juglans regia*; S-CAT is the distinguishing factor that has a more significant influence on the SOC content of *Malus pumila*; SBD is the factor that has the highest contribution to the SOC content of *Prunus armeniaca*, *Prunus persica*, and *Zanthoxylum bungeanum*; the SOC content of the control wasteland is more influenced by S-CAT and the number of soil fungi (Fig. 8). This is a good indication that the various indicators of soil factors and soil microorganisms are not singularly involved in soil physiology and biochemistry, but that the various factors interact and synergize to promote changes in SOC (Grayston et al., 1998).

Influence pathways of soil organic carbon in different economic forests

In the structural equation model (Fig. 9), soil physical and chemical properties have both a direct effect on SOC content and an indirect effect on SOC content through their influence on soil microbial indicators and soil enzyme activity. The higher the SBD, the lower the soil porosity, the less permeable and less aerated the soil is, which is not conducive to microbial survival and plant root growth, and the soil porosity is closely related to the decomposition and conversion of apoplastic matter into SOC (Jiang et al., 2021). pH and CEC affect SOC by influencing the number of soil microorganisms and enzyme activity (Liu et al., 2013). pH affects carbon fixation and soil accumulation mainly through microbial activity, which is only suitable for neutral environments. The factors that contribute to changes in SOC are complex, and when conserving SOC, more attention should be paid to improving soil properties while improving the condition of microbial communities also plays a positive role in SOC accumulation.

Conclusions

The SOC content of different economic forests ranged from 10.17–17.20 g/kg, and the SOC content at 0–100 cm soil depth was in descending order: *Malus pumila*, *Zanthoxylum bungeanum*, *Juglans regia*, *Prunus armeniaca*, *Prunus persica*, and wasteland, which indicated that *Malus pumila* was the preferred choice for economic forest planting in Gangu County and planting *Malus pumila* could improve the soil carbon sequestration level in the area to a certain extent. Soil microbial population, soil enzyme activity, and SBD significantly directly affect SOC content. SBD, SWC, CEC, and pH can also indirectly influence

soil organic carbon content by affecting soil enzyme activity and soil microbial population, among which, S-CAT is the factor that has a more significant effect on the SOC content of *Malus pumila*; SBD is the factor that contributes most to SOC content of *Zanthoxylum bungeanum*, therefore, agricultural cultivation needs to improve and adjust the growing environment of crops according to the actual situation.

Declarations

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Compliance with ethical standards

Conflict of interest The authors declare no competing interests.

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Figures

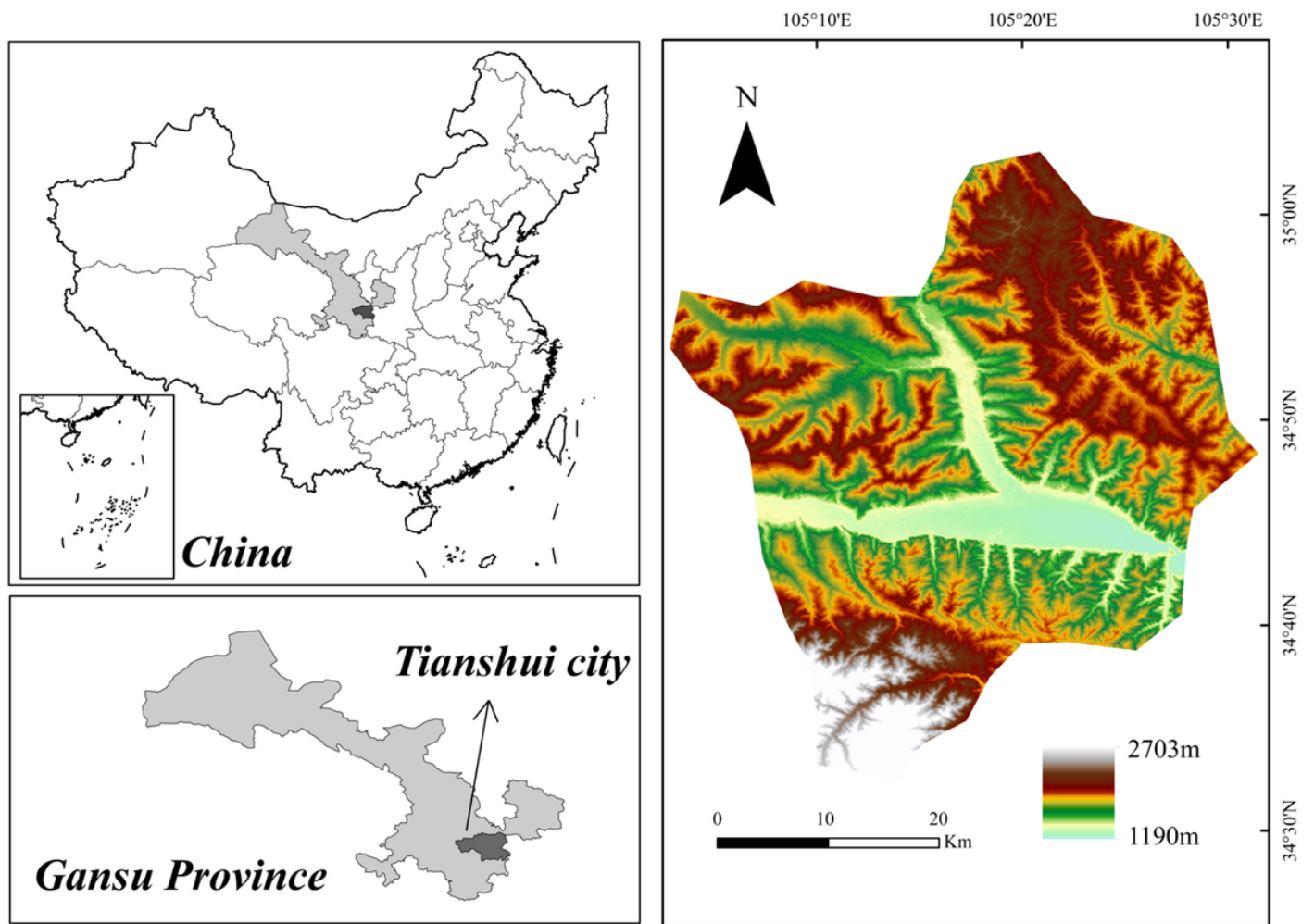


Figure 1

Geographical of the study area



Figure 2

Field sampling

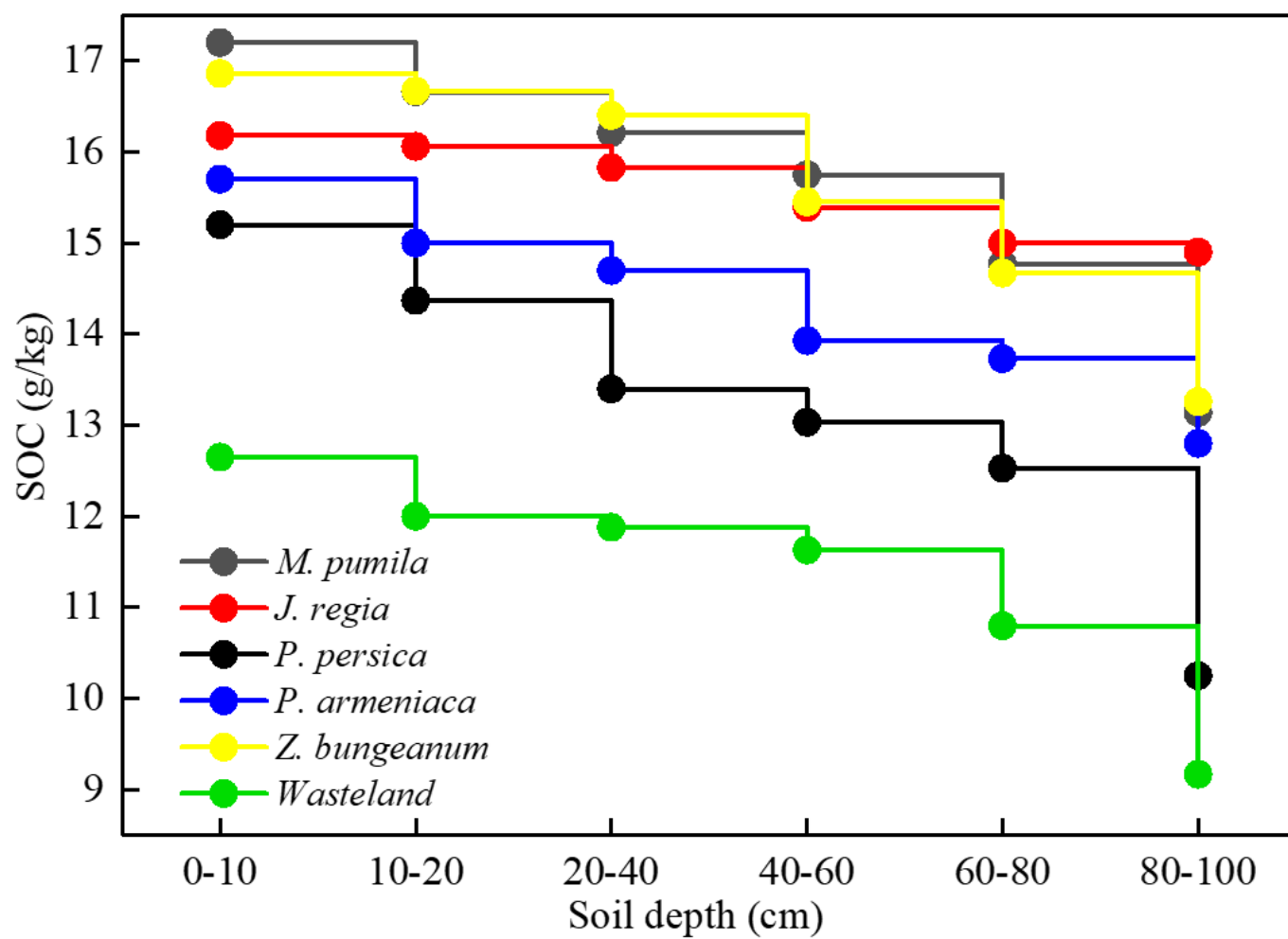


Figure 3

Fig. 2 Distribution of SOC in different economic forest vegetations

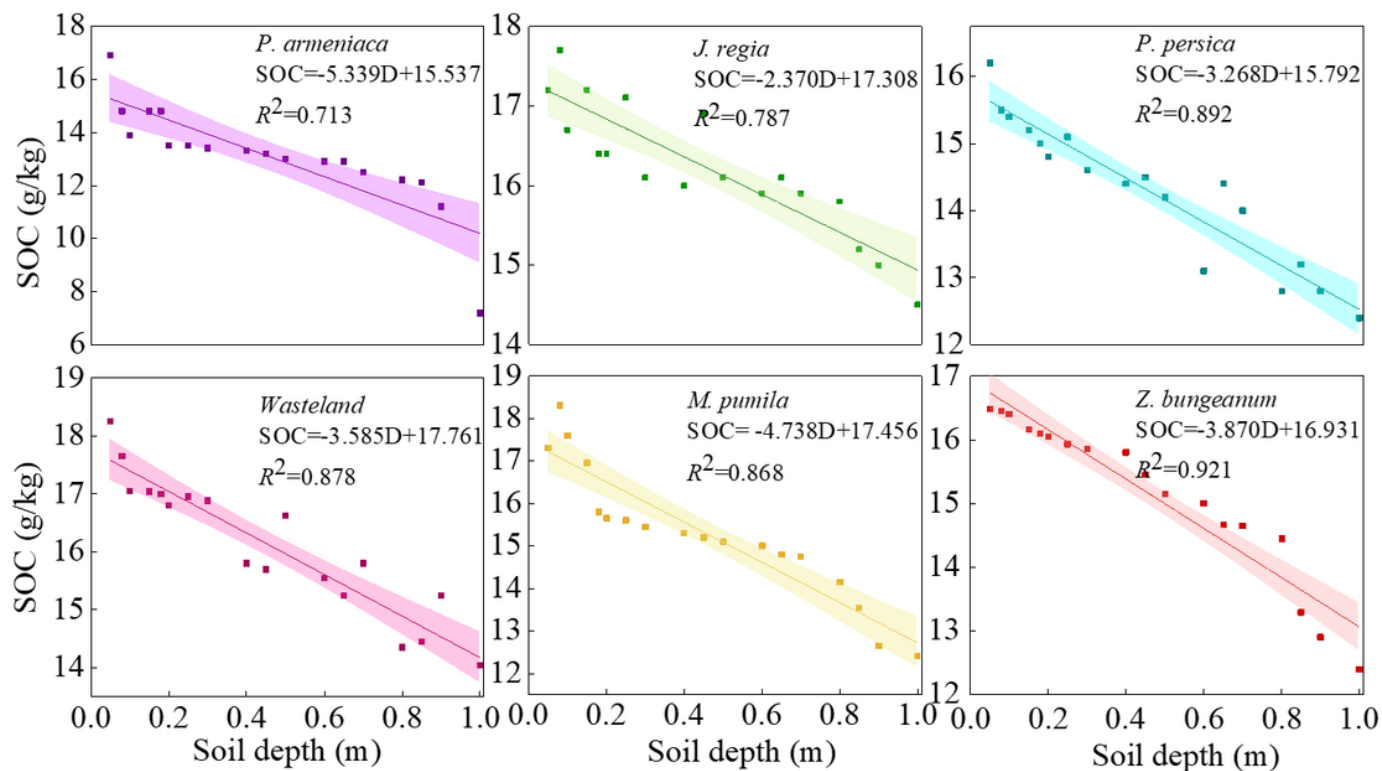


Figure 4

Fig. 3 Regression results for the relationships between SOC content and soil depth in the *Malus pumila*, *Juglans regia*, *Prunus persica*, *Prunus armeniaca*, *Zanthoxylum bungeanum* and wasteland . The color shade shows the 95% confidence intervals of the regression equation. Parameter definitions: SOC, Soil organic carbon content; D, soil depth.

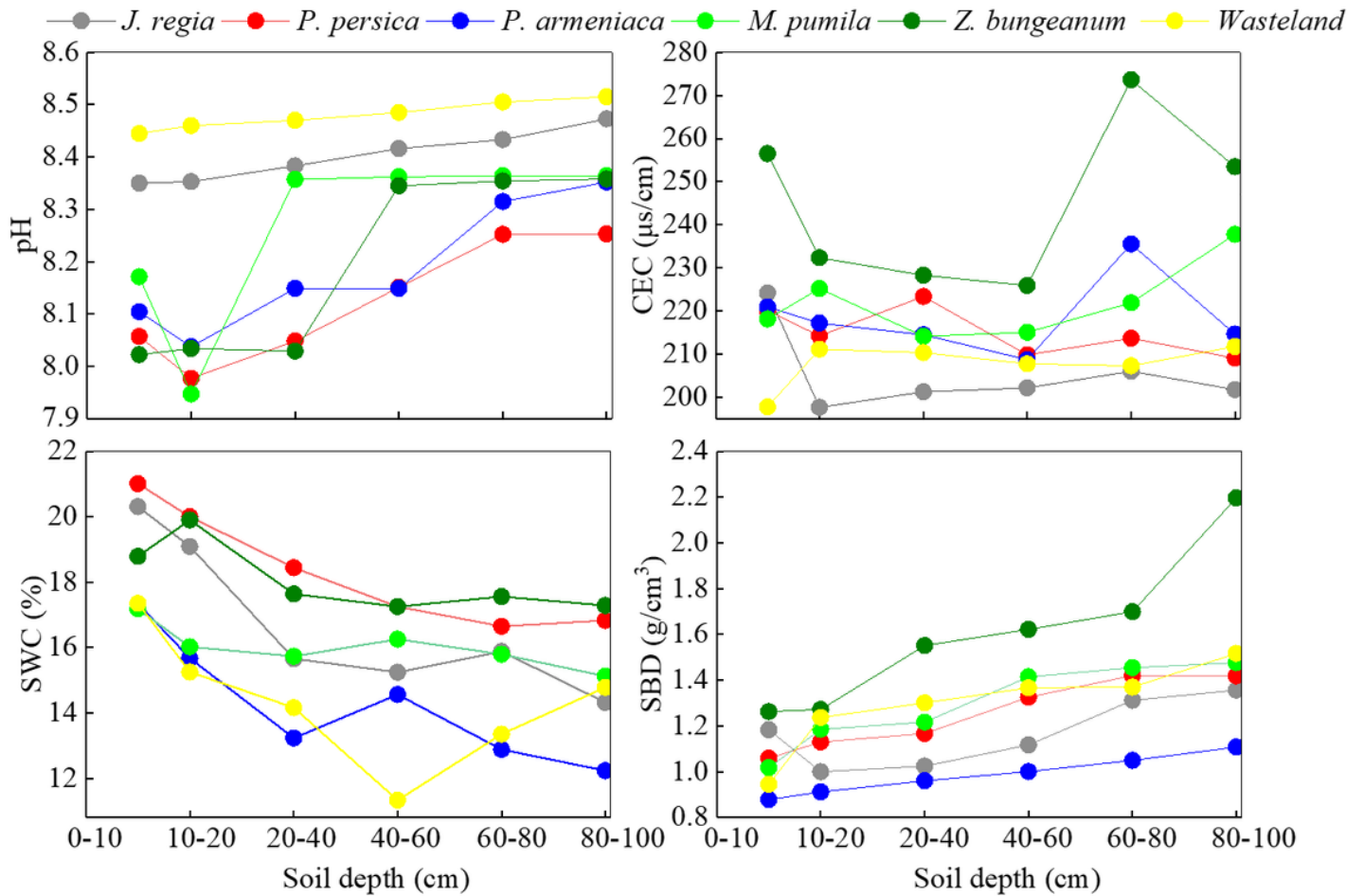


Figure 5

Figure .4 Soil property parameters of 0-100cm soil layer of different economic forest vegetation

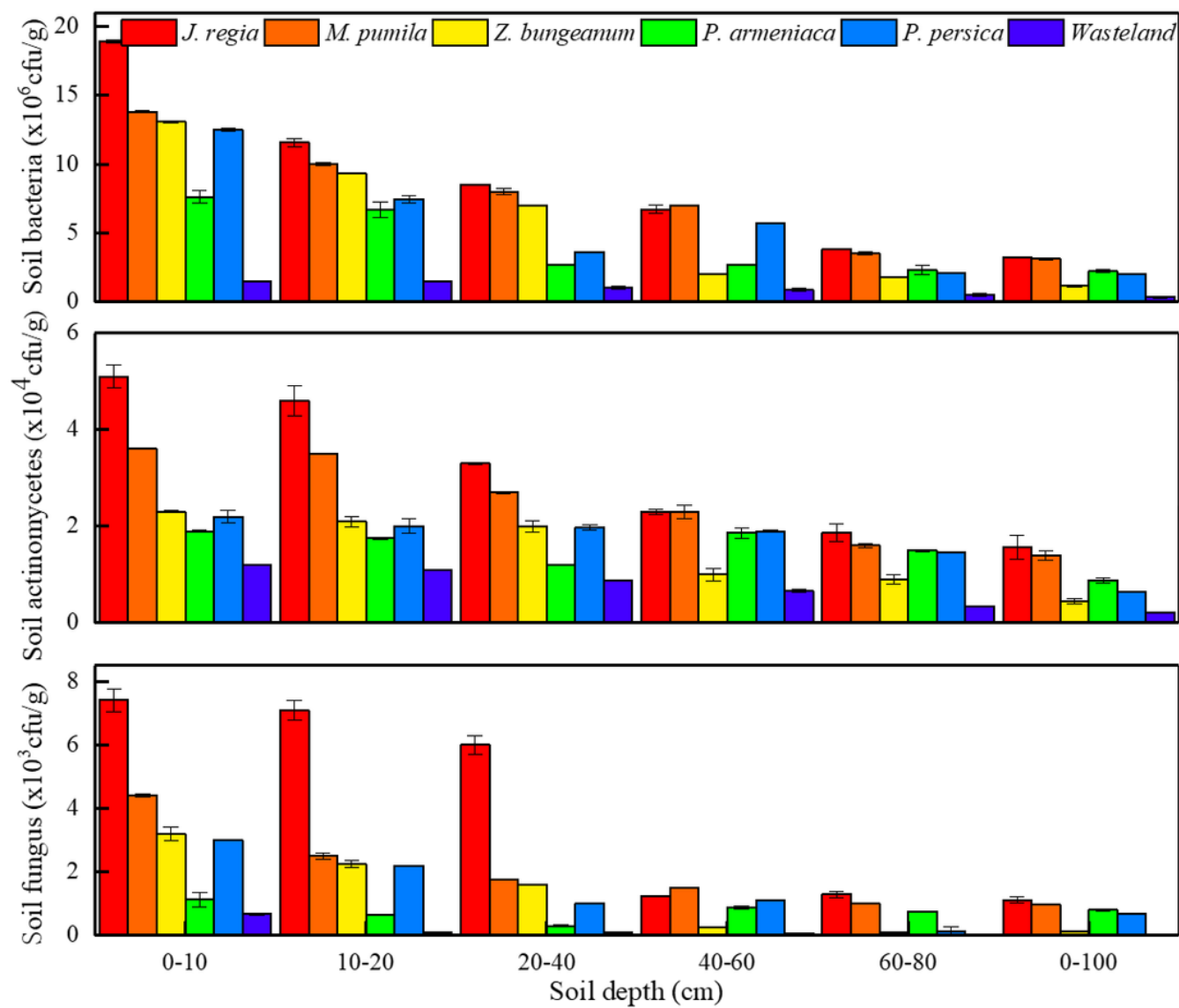


Figure 6

Fig.5 Number of soil microorganisms in different economic forest vegetation under 0-100cm soil depth

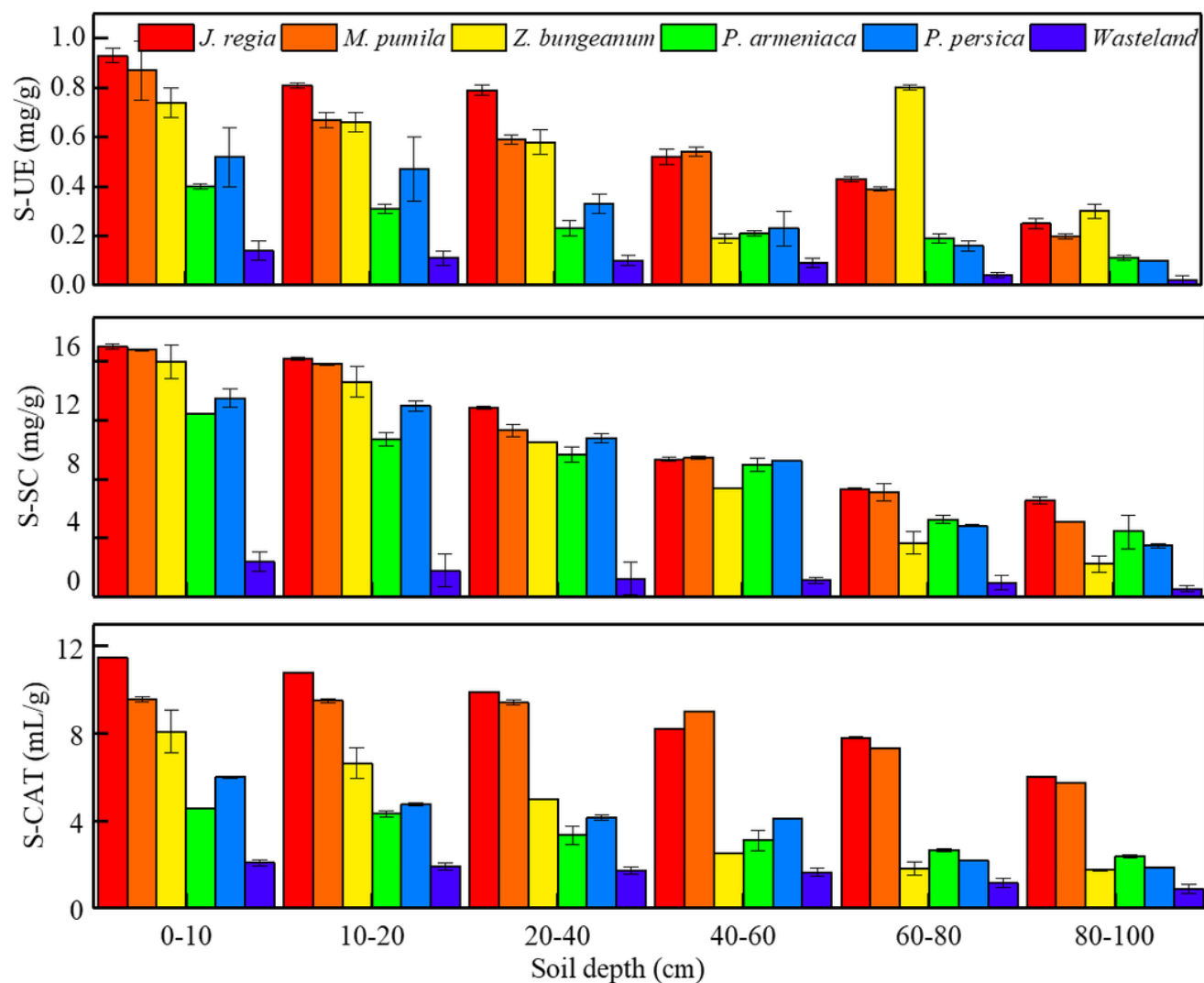


Figure 7

Fig.6 Soil enzyme activities of different economic forest vegetation under 0-100 cm soil depth

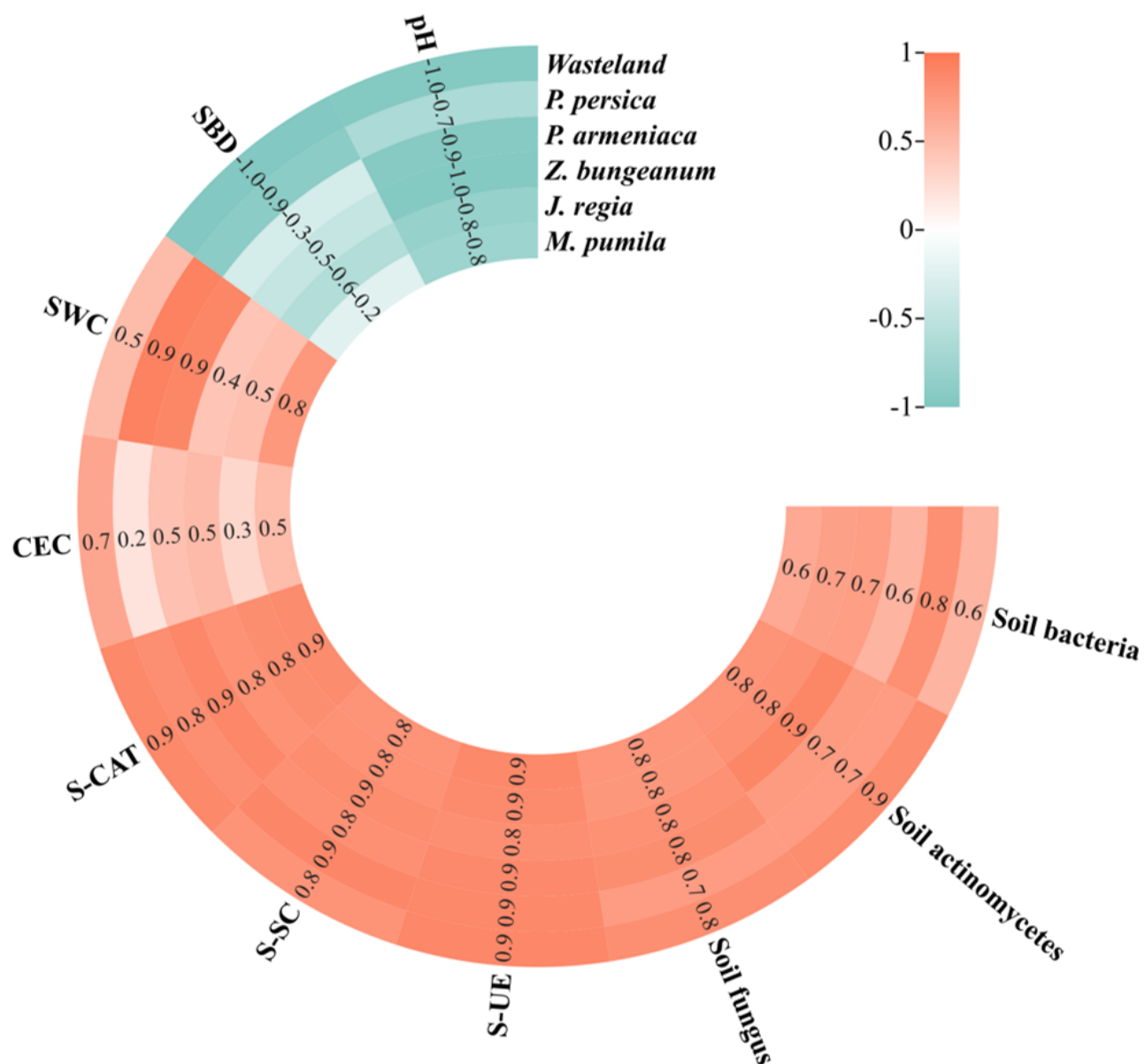


Figure 8

Fig. 7 Pearson's relationship between SOC content and simple soil physicochemical properties (SWC, SBD, pH, CEC), soil enzyme activities (S-UE, S-SC, S-CAT) and soil microbial populations (Soil bacteria, Soil actinomycetes, Soil fungus).

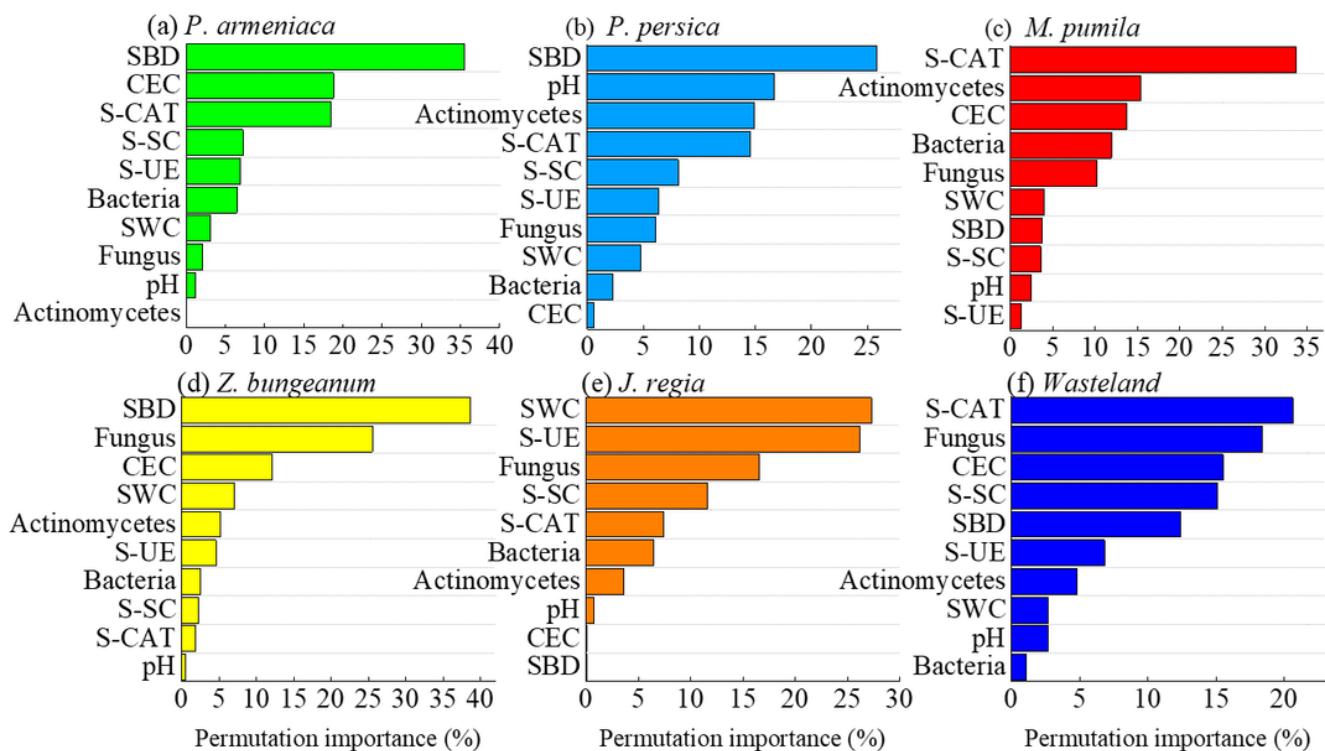


Figure 9

Fig. 8 Permutation importance results

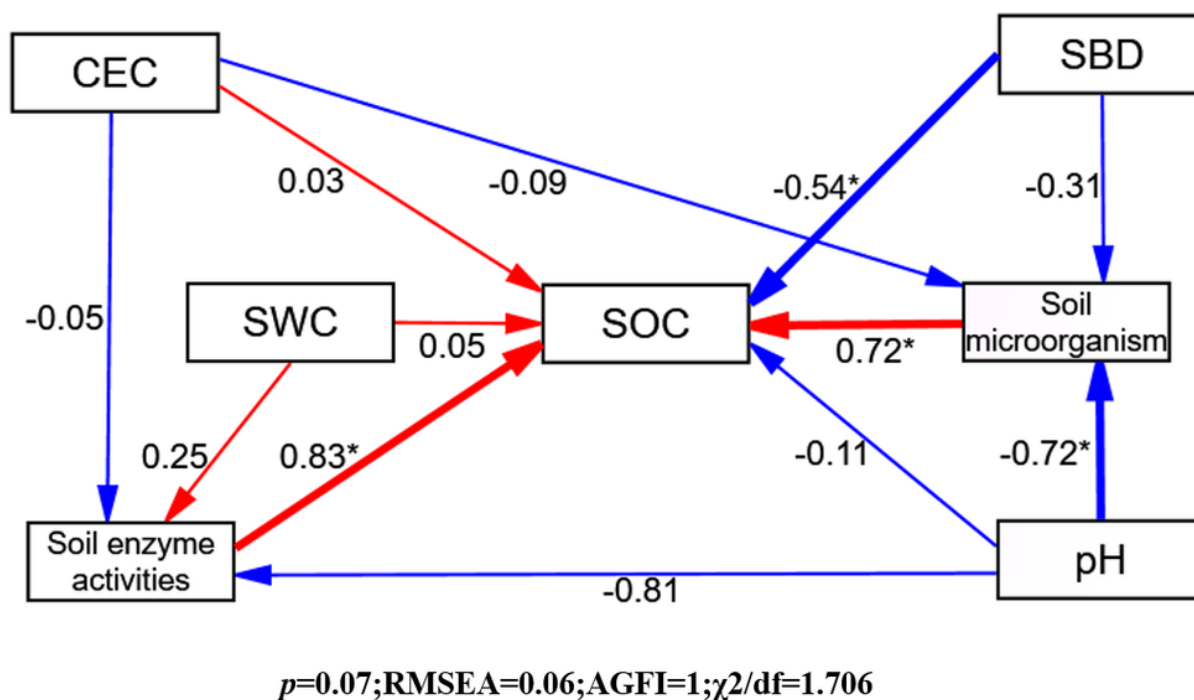


Figure 10

Fig.9 Structural equation model of the relationship between SOC and soil physical and chemical properties, microbial population and soil enzyme activity

