**Table S1** Description of 7 long-term experiments of National Ecosystem Research Network

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sampling sites** | **Longitude, Latitude** | **Soil taxonomy (USDA)** | **Onset of experiments** | **Average annual precipitation and temperature** | **Crop** | **Amount of chemical fertilizer applied (kg ha-1).** | | |
| **NPK, N+ P2O5+K2O; NK, no P2O5;** | | |
| **Ctrl, no fertilization.** | | |
| **Hailun (HL)** | 47°27′00″N, | Histosols | 1990 | 562.16mm, | Maize soybean rotation: Maize was sown at the beginning of May and harvested at the end of September. Next year, soybean was sown at the end of April and harvest in September. | 20.25 | 51.8 | 30 |
| 126°37′48″E | 2.75℃ | 112.5 | 45 | 30 |
| **Shenyang (SY)** | 41°31′12″N, | Paleudalf | 1979 | 691.3mm, | Maize soybean rotation: Maize was sown at the beginning of May and harvested at the end of September. Next year, soybean was sown at the end of April and harvest in September. | 30 | 90 | 60 |
| 123°24′00″E | 8.61℃ | 120 | 60 | 30 |
| **Fengqiu (FQ)** | 35°1′12″N, | Inceptisol | 1990 | 604.8mm, | Wheat maize rotation: Wheat was planted at the beginning of November and harvested in mid-May of the the following year). After wheat harvest, Maize was sown in early June and harvested in the mid-September) | 187.5 | 93.8 | 93.8 |
| 114°31′48″E | 15.24℃ | 165 | 82.5 | 82.5 |
| **Changwu (CW)** | 35°12′00″N, | Cumulic Haplustoll | 1984 | 574.62mm, | Wheat monocropping: Wheat was sown in mid-September and harvested at the end of June in the following year) | 90 | 79 | 90 |
| 107°40′12″E | 9.85℃ | 90 | 79 | 90 |
| **Yanting (YT)** | 31°16′12″N, | Entisol | 1980 | 811.83mm, | Wheat maize rotation: Wheat was sown at the beginning of November and harvested in mid-May of the the following year). After wheat harvest, Maize was sown in early June and harvested in the mid-September) | 150 | 90 | 36 |
| 105°27′00″E | 17.17℃ | 130 | 90 | 36 |
| **Qiyang (QY)** | 26°45′00″N, | Hapludult | 1982 | 1309.42mm, | Wheat maize rotation: Wheat was sown at the beginning of November and harvested in mid-May of the the following year). After wheat harvest, Maize was sown in early June and harvested in the mid-September) | 210 | 37 | 70 |
| 111°52′48″E | 18.78℃ | 90 | 16 | 30 |
| **Fukang (FK)** | 44°18′N, | Entisol | 1987 | 160mm, | Wheat monocropping: Wheat was sown in mid-September and harvested at the end of June in the following year) | 150 | 75 | 60 |
| 87°55′E | 6.6℃ |

**Table S2** Soil characteristics under different fertilization treatments at 7 long-term experiments of National Ecosystem Research Network.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sites** | **Fertilization treatments** | TN (g kg-1) | TP (g kg-1) | TK (g kg-1) | OM (g kg-1) | pH | AP  (mg kg-1) | AK  (mg kg-1) | NO3--N  (mg kg-1) | NH4+-N  (mg kg-1) | C/N | C/P | N/P |
| **HL** | **Ctrl** | 2.13±0.03a | 0.76±0.08a | 21.23±0.43a | 45.00±0.15a | 6.18±0.17a | 4.11±0.19c | 148.17±12.18a | 7.46±0.18a | 0.77±0.15a | 12.26±0.17a | 35.22±3.37a | 2.87±0.27a |
|  | **NK** | 2.17±0.12a | 0.76±0.08a | 20.72±0.06a | 46.10±2.88a | 5.92±0.05a | 7.38±0.90b | 161.67±23.62a | 8.99±1.06a | 0.93±0.11a | 12.33±0.12a | 35.73±1.86a | 2.90±0.16a |
|  | **NPK** | 2.17±0.06a | 0.73±0.05a | 21.11±0.64a | 45.80±0.81a | 5.89±0.02a | 17.13±0.48a | 178.04±7.95a | 9.6±0.32a | 0.64±0.04a | 12.25±0.17a | 36.82±1.95a | 3.00±0.14a |
| **SY** | **Ctrl** | 0.88±0.02b | 0.36±0.03b | 21.10±0.34a | 15.90±0.42b | 5.70±0.14a | 2.00±0.14c | 86.27±1.72b | 14.87±9.79a | 1.64±0.42a | 10.44±0.08a | 26.05±1.24b | 2.50±0.12b |
|  | **NK** | 1.01±0.02a | 0.35±0.00b | 21.13±0.27a | 17.87±0.19a | 4.99±0.02b | 2.73±0.14b | 84.03±4.30b | 20.09±4.14a | 2.09±0.35a | 10.26±0.08a | 29.61±0.31a | 2.89±0.05a |
|  | **NPK** | 1.00±0.02a | 0.50±0.01a | 21.45±0.16a | 17.47±0.53a | 5.14±0.01b | 5.65±0.20a | 104.66±6.05a | 9.42±4.05a | 2.56±0.30a | 10.16±0.09a | 20.14±0.59c | 1.98±0.06c |
| **FQ** | **Ctrl** | 0.48±0.02c | 0.51±0.01b | 19.50±0.31a | 7.27±0.09b | 8.58±0.08a | 1.37±0.07c | 68.33±4.48c | 7.99±0.87b | 1.85±0.20a | 8.86±0.23a | 8.27±0.25a | 0.94±0.05ab |
|  | **NK** | 0.54±0.02b | 0.51±0.01b | 19.82±0.35a | 7.27±0.23b | 8.23±0.02b | 2.87±0.16b | 412.73±17.62a | 68.06±3.58a | 0.26±0.06b | 7.81±0.14b | 8.26±0.13a | 1.06±0.01a |
|  | **NPK** | 0.75±0.03a | 0.87±0.03a | 19.44±0.16a | 11.10±0.30a | 8.07±0.01c | 16.08±0.57a | 214.05±10.20b | 59.14±12.72a | 0.40±0.08b | 8.59±0.13a | 7.41±0.23b | 0.86±0.03b |
| **CW** | **Ctrl** | 0.92±0.01b | 0.79±0.03b | 21.02±0.22a | 12.53±0.24b | 8.36±0.01a | 4.45±0.19b | 187.88±12.96b | 3.41±0.38b | 0.62±0.13a | 7.93±0.05a | 9.17±0.15b | 1.16±0.03b |
|  | **NK** | 1.03±0.03a | 0.72±0.02b | 20.60±0.43a | 13.20±0.44b | 8.02±0.04a | 4.97±0.52b | 172.07±4.42b | 56.12±9.00a | 0.50±0.14a | 7.44±0.31a | 10.68±0.24a | 1.44±0.07a |
|  | **NPK** | 1.05±0.01a | 1.16±0.05a | 20.92±0.30a | 15.10±0.17a | 8.46±0.30a | 22.35±1.30a | 276.85±15.52a | 8.79±1.98b | 0.66±0.03a | 8.32±0.18a | 7.55±0.28c | 0.91±0.03c |
| **YT** | **Ctrl** | 0.71±0.02b | 0.58±0.01b | 21.35±0.05a | 9.13±0.43b | 8.34±0.02a | 3.26±0.06b | 106.55±7.10a | 4.46±0.06c | 1.33±0.18ab | 7.42±0.16a | 9.15±0.53a | 1.23±0.04a |
|  | **NK** | 0.79±0.04b | 0.60±0.02b | 20.96±0.13a | 9.80±0.59b | 8.42±0.06a | 1.86±0.08b | 112.72±8.82a | 6.81±0.59b | 1.44±0.25a | 7.22±0.08a | 9.52±0.31a | 1.32±0.03a |
|  | **NPK** | 0.91±0.03a | 1.06±0.07a | 21.14±0.59a | 12.00±0.40a | 8.32±0.02a | 14.58±1.38a | 129.19±10.00a | 15.05±0.20a | 0.75±0.01b | 7.68±0.13a | 6.62±0.25b | 0.86±0.03b |
| **QY** | **Ctrl** | 0.93±0.01b | 0.46±0.01b | 14.20±0.13a | 13.73±0.12b | 5.46±0.03a | 2.56±0.48b | 37.18±0.51c | 2.70±0.18b | 3.81±0.64a | 8.57±0.10b | 17.32±0.08a | 2.02±0.03a |
|  | **NK** | 0.95±0.04b | 0.45±0.01b | 14.44±0.22a | 13.00±0.31b | 4.04±0.03c | 1.82±0.31b | 242.43±6.28b | 11.45±1.17a | 1.64±0.17b | 7.92±0.16c | 16.63±0.16b | 2.10±0.06a |
|  | **NPK** | 1.31±0.01a | 1.32±0.02a | 14.76±0.30a | 21.10±0.20a | 4.25±0.02b | 24.40±0.60a | 283.88±2.84a | 3.26±1.27b | 3.83±0.71a | 9.34±0.04a | 9.27±0.10c | 0.99±0.01b |
| **FK** | **Ctrl** | 0.54±0.02b | 0.99±0.02b | 21.22±0.15ab | 8.63±0.54b | 9.09±0.02a | 4.36±0.25b | 279.21±8.15ab | 1.81±0.11b | 0.98±0.04a | 9.21±0.23a | 5.07±0.20b | 0.55±0.02c |
|  | **NK** | 0.65±0.02a | 0.98±0.01b | 21.32±0.36a | 10.33±0.58b | 8.90±0.03b | 2.34±0.11b | 295.71±8.70a | 5.40±0.22a | 0.63±0.12a | 9.21±0.23a | 6.14±0.34a | 0.67±0.02a |
|  | **NPK** | 0.71±0.02a | 1.11±0.03a | 20.39±0.17b | 12.00±0.21a | 8.89±0.02b | 12.08±1.51a | 235.30±23.28b | 5.05±0.16a | 0.79±0.14a | 9.86±0.28a | 6.28±0.09a | 0.64±0.03b |

OM, organic matter; TN, total nitrogen; TP, total phosphorus; TK, total potassium; NH4+-N, ammonia nitrogen; NO3--N, nitrate nitrogen; AP, available phosphorus; AK, available potassium, C/N, the ratio of soil organic carbon to total nitrogen; C/P, the ratio of soil organic carbon to total phosphorus; N/P, the ratio of total nitrogen to total phosphorus. HL, Hailun; SY, Shengyang; FQ, Fengqiu; CW, Changwu; YT, Yangting; QY, Qiyang; FK, Fukang. Ctrl, no fertilization; NK, nitrogen and phosphorus inputs; NPK, nitrogen, phosphorus and potassium inputs. Different lowercase letters indicate significant differences of individual parameters under the same fertilization treatment across sampling sites based on Tukey’s HSD tests (*P* < 0.05).

**Table S3** Theα-diversity of bacterial, fungal, protist and nematode communites.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Organisms** | **Sites** | **Fertilization treatments** | **α-diversity** | | |
| **Shannon** | **Chao 1** | **Evenness** |
| **Bacteria** | **HL** | **Ctrl** | 10.07±0.06 | 6047.47±97.03 | 0.84±0.00 |
|  | **NK** | 10.12±0.05 | 5980.02±128.52 | 0.85±0.00 |
|  | **NPK** | 10.16±0.05 | 6058.21±271.26 | 0.85±0.00 |
| **SY** | **Ctrl** | 9.9±0.11 | 5588.16±270.2 | 0.84±0.01 |
|  | **NK** | 9.4±0.06 | 4292.35±109.24 | 0.82±0.00 |
|  | **NPK** | 9.31±0.20 | 3593.60±922.28 | 0.80±0.02 |
| **FQ** | **Ctrl** | 10.08±0.18 | 6437.93±142.39 | 0.84±0.02 |
|  | **NK** | 10.58±0.01 | 7439.32±90.13 | 0.87±0.00 |
|  | **NPK** | 10.54±0.12 | 7216.89±382.65 | 0.87±0.00 |
| **CW** | **Ctrl** | 10.57±0.04 | 6021.07±62.36 | 0.88±0.00 |
|  | **NK** | 10.52±0.02 | 6228.47±264.96 | 0.88±0.00 |
|  | **NPK** | 10.46±0.02 | 6028.44±102.27 | 0.87±0.00 |
| **YT** | **Ctrl** | 10.86±0.07 | 7392.63±243.13 | 0.89±0.00 |
|  | **NK** | 10.78±0.15 | 7351.18±464.86 | 0.88±0.01 |
|  | **NPK** | 10.86±0.03 | 7365.71±131.90 | 0.89±0.00 |
| **QY** | **Ctrl** | 9.41±0.03 | 3900.75±38.03 | 0.83±0.00 |
|  | **NK** | 6.84±0.02 | 2081.59±116.86 | 0.66±0.00 |
|  | **NPK** | 8.43±0.02 | 2520.41±236.35 | 0.78±0.00 |
| **FK** | **Ctrl** | 10.31±0.13 | 5490.79±83.79 | 0.87±0.01 |
|  | **NK** | 10.57±0.04 | 6740.19±92.28 | 0.87±0.00 |
|  | **NPK** | 10.43±0.03 | 6126.64±203.71 | 0.87±0.00 |
| **Two-way ANOVA** | **Sites** | **F = 303.70** | **F = 89.82** | **F = 134.61** |
| ***P* < 0.001** | ***P* < 0.001** | ***P* < 0.001** |
| **Fertilization treatments** | **F = 27.06** | F = 1.72 | **F = 20.54** |
| ***P <* 0.001** | P = 0.19 | ***P <* 0.001** |
| **Interaction** | **F = 36.36** | **F = 5.04** | **F = 28.40** |
| ***P* < 0.001** | ***P* < 0.001** | ***P* = 0.001** |
| **Fungi** | **HL** | **Ctrl** | 6.73±0.04 | 647.99±13.92 | 0.75±0.00 |
|  | **NK** | 6.62±0.28 | 648.55±30.35 | 0.74±0.03 |
|  | **NPK** | 6.87±0.13 | 788.76±97.32 | 0.75±0.01 |
| **SY** | **Ctrl** | 6.66±0.07 | 729.39±32.82 | 0.73±0.01 |
|  | **NK** | 6.18±0.14 | 588.96±31.84 | 0.70±0.02 |
|  | **NPK** | 5.91±0.17 | 768.61±37.96 | 0.66±0.01 |
| **FQ** | **Ctrl** | 5.27±0.15 | 418.14±14.72 | 0.62±0.02 |
|  | **NK** | 6.40±0.17 | 457.66±29.65 | 0.74±0.02 |
|  | **NPK** | 6.55±0.15 | 400.96±43.87 | 0.61±0.13 |
| **CW** | **Ctrl** | 6.30±0.16 | 490.94±45.48 | 0.72±0.02 |
|  | **NK** | 6.18±0.15 | 453.86±13.91 | 0.72±0.02 |
|  | **NPK** | 5.64±0.07 | 466.73±52.46 | 0.66±0.01 |
| **YT** | **Ctrl** | 7.08±0.07 | 607.07±8.59 | 0.79±0.01 |
|  | **NK** | 6.04±1.10 | 551.34±84.70 | 0.68±0.12 |
|  | **NPK** | 7.44±0.08 | 870.19±133.4 | 0.79±0.01 |
| **QY** | **Ctrl** | 4.37±0.25 | 445.36±43.09 | 0.52±0.02 |
|  | **NK** | 5.22±0.12 | 449.36±57.34 | 0.63±0.00 |
|  | **NPK** | 5.25±0.27 | 471.75±30.23 | 0.62±0.03 |
| **FK** | **Ctrl** | 5.90±0.17 | 424.33±36.43 | 0.69±0.01 |
|  | **NK** | 4.61±0.93 | 407.87±50.54 | 0.55±0.10 |
|  | **NPK** | 6.58±0.42 | 568.44±96.31 | 0.74±0.03 |
| **Two-way ANOVA** | **Sites** | **F = 9.67** | **F = 11.96** | **F = 4.32** |
| ***P* < 0.001** | ***P* < 0.001** | ***P* < 0.001** |
| **Fertilization treatments** | F = 2.54 | **F = 5.80** | F = 0.15 |
| *P* = 0.09 | ***P* = 0.005** | *P =* 0.86 |
| **Interaction** | **F = 2.87** | F = 1.27 | **F = 1.93** |
| ***P* < 0.001** | *P =* 0.27 | ***P =* 0.05** |
| **Protists** | **HL** | **Ctrl** | 2.75±0.2 | 26.63±1.71 | 0.59±0.02 |
|  | **NK** | 2.66±0.15 | 31.43±2.6 | 0.55±0.04 |
|  | **NPK** | 2.81±0.05 | 28.07±0.43 | 0.59±0.01 |
| **SY** | **Ctrl** | 2.66±0.02 | 27.25±1.81 | 0.60±0.01 |
|  | **NK** | 3.19±0.24 | 28±2.75 | 0.72±0.03 |
|  | **NPK** | 2.7±0.27 | 27.2±5.23 | 0.64±0.11 |
| **FQ** | **Ctrl** | 2.95±0.23 | 19.67±1.76 | 0.72±0.03 |
|  | **NK** | 2.88±0.24 | 26.93±1.5 | 0.66±0.06 |
|  | **NPK** | 3.24±0.15 | 24.63±1.51 | 0.73±0.03 |
| **CW** | **Ctrl** | 3.05±0.11 | 30.37±3.82 | 0.64±0.02 |
|  | **NK** | 3.17±0.12 | 29.92±1.08 | 0.69±0.03 |
|  | **NPK** | 3.64±0.1 | 30.37±1.54 | 0.75±0.01 |
| **YT** | **Ctrl** | 3.35±0.15 | 28.88±2.45 | 0.69±0.02 |
|  | **NK** | 3.36±0.24 | 28.8±2.48 | 0.71±0.03 |
|  | **NPK** | 2.97±0.46 | 29.6±3.43 | 0.64±0.1 |
| **QY** | **Ctrl** | 2.51±0.23 | 27.87±1.14 | 0.51±0.04 |
|  | **NK** | 2.73±0.05 | 26.92±2.1 | 0.61±0.03 |
|  | **NPK** | 3.51±0.34 | 36.2±5.27 | 0.7±0.04 |
| **FK** | **Ctrl** | 3.16±0.06 | 24.17±2.59 | 0.74±0.02 |
|  | **NK** | 3.49±0.2 | 26.67±1.45 | 0.77±0.02 |
|  | **NPK** | 3.33±0.06 | 34.35±2.03 | 0.71±0.01 |
| **Two-way ANOVA** | **Sites** | **F = 3.84** | F = 1.24 | **F = 5.15** |
| ***P* = 0.004** | *P* = 0.06 | ***P* < 0.001** |
| **Fertilization treatments** | F = 2.72 | **F = 2.19** | F = 1.53 |
| *P* = 0.08 | ***P* = 0.04** | *P* = 0.23 |
| **Interaction** | F = 1.88 | F = 3.41 | F = 1.54 |
| *P* = 0.07 | *P* = 0.29 | *P* = 0.15 |
| **Nematodes** | **HL** | **Ctrl** | 4.08±0.17 | 123.45±10.80 | 0.67±0.02 |
|  | **NK** | 3.72±0.34 | 129.83±14.95 | 0.60±0.04 |
|  | **NPK** | 3.64±0.36 | 110.06±5.86 | 0.60±0.05 |
| **SY** | **Ctrl** | 3.81±0.37 | 119.71±11.31 | 0.63±0.06 |
|  | **NK** | 3.32±0.40 | 128.60±57.00 | 0.57±0.02 |
|  | **NPK** | 3.37±0.43 | 70.70±22.18 | 0.60±0.04 |
| **FQ** | **Ctrl** | 3.47±0.05 | 79.83±14.22 | 0.61±0.01 |
|  | **NK** | 4.16±0.12 | 80.00±6.08 | 0.71±0.01 |
|  | **NPK** | 4.16±0.19 | 90.08±18.77 | 0.71±0.01 |
| **CW** | **Ctrl** | 3.58±0.34 | 80.08±5.48 | 0.63±0.05 |
|  | **NK** | 3.26±0.32 | 80.59±10.25 | 0.57±0.06 |
|  | **NPK** | 3.24±0.15 | 125.25±24.42 | 0.52±0.02 |
| **YT** | **Ctrl** | 4.34±0.17 | 86.38±7.13 | 0.71±0.02 |
|  | **NK** | 4.18±0.42 | 145.61±47.79 | 0.67±0.07 |
|  | **NPK** | 5.03±0.16 | 159.54±45.89 | 0.75±0.01 |
| **QY** | **Ctrl** | 4.73±0.28 | 151.18±18.67 | 0.70±0.02 |
|  | **NK** | 4.86±0.21 | 153.37±16.45 | 0.74±0.02 |
|  | **NPK** | 4.33±0.45 | 120.05±19.88 | 0.69±0.06 |
| **FK** | **Ctrl** | 3.95±0.13 | 115.30±36.81 | 0.65±0.01 |
|  | **NK** | 3.74±0.22 | 111.42±26.16 | 0.62±0.04 |
|  | **NPK** | 3.36±0.50 | 103.44±18.50 | 0.57±0.07 |
| **Two-way ANOVA** | **Sites** | **F = 7.84** | F = 1.91 | F = 5.65 |
| ***P* < 0.001** | *P* = 0.10 | *P* = 0.10 |
| **Fertilization treatments** | F = 0.32 | F = 0.32 | F = 0.71 |
| *P* = 0.73 | *P* = 0.73 | *P* = 0.50 |
| **Interaction** | F = 1.21 | F = 0.91 | F = 1.18 |
| *P* = 0.31 | *P* = 0.55 | *P* = 0.33 |

HL, Hailun; SY, Shengyang; FQ, Fengqiu; CW, Changwu; YT, Yangting; QY, Qiyang; FK, Fukang. Ctrl, no fertilization; NK, nitrogen and phosphorus inputs; NPK, nitrogen, phosphorus and potassium inputs.

**Table S4** The correlation and slopes of distance-decay curves for functional potential associated with carbon, nitrogen, phosphorus, and sulfur cycling. The slopes were pairwise compared between two fertilization treatments by Wilcoxon rank-sum test. \*, *P* < 0.05; \*\*, *P* < 0.01; \*\*\*, *P* < 0.001; ns, nonsignificant.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Function** | **Fertilization treatments** | **Slope** | **P** | **R-squared** | | **vs NK** | **vs NPK** |
| **Carbon cycling** | **Ctrl** | -0.014 | \*\* | | 0.041 | ns | \*\*\* |
| **NK** | -0.021 | \*\*\* | | 0.1616 |  | \*\*\* |
| **NPK** | -0.002 | ns | | -0.0023 |  |  |
| **Nitrogen**  **cycling** | **Ctrl** | -0.015 | \*\* | | 0.046 | ns | \*\*\* |
| **NK** | -0.020 | \*\*\* | | 0.1441 |  | \*\*\* |
| **NPK** | -0.001 | ns | | -0.0041 |  |  |
| **Phosphorus**  **cycling** | **Ctrl** | -0.013 | \*\* | | 0.0452 | ns | \*\*\* |
| **NK** | -0.019 | \*\*\* | | 0.1374 |  | \*\*\* |
| **NPK** | -0.001 | ns | | -0.0043 |  |  |
| **Sulfur**  **cycling** | **Ctrl** | -0.016 | \*\*\* | | 0.048 | ns | \*\*\* |
| **NK** | -0.022 | \*\*\* | | 0.1514 |  | \*\*\* |
| **NPK** | -0.001 | ns | | -0.0041 |  |  |

**Table S5** Fitting index of partial least squares structural equation modeling (PLS-SEM).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Cronbach’s alpha** | **Composite reliability** | **Average variance extracted** | **Communality** | **R2** | **Goodness-of-fit** |
| Soil environmental factors | AP and TP | 0.72 | 0.874 | 0.777 | 0.311 |  | 0.641 |
| C/P and N/P | 0.967 | 0.984 | 0.968 | 0.715 |  |
| Community assembly | Bacteria | 1 | 1 | 1 | 1 | 0.524 |
| Fungi | 1 | 1 | 1 | 1 | 0.581 |
| Protists | 1 | 1 | 1 | 1 | 0.331 |
| Nematodes | 1 | 1 | 1 | 1 | 0.218 |
| Biotic community | β-diversity | 0.85 | 0.728 | 0.522 | 0.503 | 0.677 |
| Network stability | 0.921 | 0.763 | 0.623 | 0.801 | 0.654 |
| Soil microbial functional potential | Soil microbial functional potential | 0.994 | 0.995 | 0.981 | 0.931 | 0.583 |

TP, total phosphorus; AP, available phosphorus; C/P, the ratio of soil organic carbon to total phosphorus; N/P, the ratio of total nitrogen to total phosphorus.

图形用户界面, 图示

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**Figure S1** Distance-decay relationships of the biotic community under three fertilization treatments across sampling sites. Similarity of bacterial (a), fungal (b), protist (c) and nematode (d) communities against geographic distances across sampling sites. The bar graph represents the value of the slope. The slopes are pairwise compared under three fertilization treatments by permutation tests. Ctrl, no fertilization; NK, nitrogen and phosphorus inputs; NPK, nitrogen, phosphorus and potassium inputs. \*, *P* < 0.05; \*\*, *P* < 0.01; \*\*\*, *P* < 0.001; ns, nonsignificant.

图表, 箱线图

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**Figure S2** Differences of the biotic α-diversity under three fertilization treatments across sampling sites. Different lowercase letters indicate significant differences of individual parameters under the same fertilization treatment across sampling sites based on Tukey’s HSD tests (*P* < 0.05). Black lines in boxes represent mean values. HL, Hailun; SY, Shengyang; FQ, Fengqiu; CW, Changwu; YT, Yangting; QY, Qiyang; FK, Fukang; Ctrl, no fertilization; NK, nitrogen and phosphorus inputs; NPK, nitrogen, phosphorus and potassium inputs.

图表, 散点图

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**Figure S3** Principal coordinates analysis (PCoA) of the dissimilarity (Bray-Curtis distances) of the bacterial (a), fungal (b), protist (c), and nematode (d) communities. HL, Hailun; SY, Shengyang; FQ, Fengqiu; CW, Changwu; YT, Yangting; QY, Qiyang; FK, Fukang. Ctrl, no fertilization; NK, nitrogen and phosphorus inputs; NPK, nitrogen, phosphorus and potassium inputs.

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**Figure S4** Correlations between soil environmental factors and the biotic community. The composition of bacterial, fungal, protist and nematode communities is represented by the first principal coordinate (PCoA1). OM, organic matter; TN, total nitrogen; TP, total phosphorus; TK, total potassium; NH4+-N, ammonia nitrogen; NO3--N, nitrate nitrogen; AP, available phosphorus; AK, available potassium, C/N, the ratio of soil organic carbon to total nitrogen; C/P, Ratio of soil organic carbon to total phosphorus; N/P, the ratio of total nitrogen to total phosphorus.

图表, 条形图, 直方图

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**Figure S5** Topological properties of bacteria-fungi-protist-nematode co-occurrence networks under different fertilization treatments. Ctrl, no fertilization; NK, nitrogen and phosphorus inputs; NPK, nitrogen, phosphorus and potassium inputs.

图表, 散点图

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**Figure S6** The distribution of connectors and module hubs based on their topological roles in bacteria-fungi-protist-nematode co-occurrence networks under different fertilization treatments. The threshold values of within-module connectivity (*Zi*) and among-module connectivity (*Pi*) for OTUs are 2.5 and 0.62, respectively. Nodes in the network can be classified into module hubs (*Zi* > 0.25, *Pi* ≤ 0.62), connectors (*Zi* ≤ 0.25, *Pi* > 0.62), and peripherals (*Zi* ≤ 0.25, *Pi* ≤ 0.62). Ctrl, no fertilization; NK, nitrogen and phosphorus inputs; NPK, nitrogen, phosphorus and potassium inputs.



**Figure S7** Differences in functional genes associated with carbon, nitrogen, phosphorus, and sulfur cycling under different fertilization treatments. Different lowercase letters indicate significant differences of individual parameters based on Tukey’s HSD tests (*P* < 0.05). Ctrl, no fertilization; NK, nitrogen and phosphorus inputs; NPK, nitrogen, phosphorus and potassium inputs.



**Figure S8** Differences in the soil microbial functional potential under the same fertilization treatments across sampling sites. Different lowercase letters indicate significant differences of individual parameters based on Tukey’s HSD tests (*P* < 0.05). Black lines in boxes represent mean values. HL, Hailun; SY, Shengyang; FQ, Fengqiu; CW, Changwu; YT, Yangting; QY, Qiyang; FK, Fukang. Ctrl, no fertilization; NK, nitrogen and phosphorus inputs; NPK, nitrogen, phosphorus and potassium inputs.

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**Figure S9** Differences in the functional potential associated with carbon, nitrogen, phosphorus, and sulfur cycling under the same fertilization treatments across sampling sites. Different lowercase letters indicate significant differences of individual parameters based on Tukey’s HSD tests (*P* < 0.05). Black lines in boxes represent mean values. HL, Hailun; SY, Shengyang; FQ, Fengqiu; CW, Changwu; YT, Yangting; QY, Qiyang; FK, Fukang. Ctrl, no fertilization; NK, nitrogen and phosphorus inputs; NPK, nitrogen, phosphorus and potassium inputs.



**Figure S10** Principal Coordinates Analysis (PCoA) of β-diversity (Bray-Curtis distance) of soil microbial functional potential, as well as β-diversity of functional potential associated with carbon, nitrogen, phosphorus, and sulfur cycling. HL, Hailun; SY, Shengyang; FQ, Fengqiu; CW, Changwu; YT, Yangting; QY, Qiyang; FK, Fukang; Ctrl, no fertilization; NK, nitrogen and phosphorus inputs; NPK, nitrogen, phosphorus and potassium inputs.



**Figure S11** Differences in the biotic α-diversity and soil microbial functional potential under different fertilization treatments across the seven long-term experimental sites. Different lowercase letters indicate significant differences of individual parameters based on Tukey’s HSD tests (*P* < 0.05). Black lines in boxes represent mean values. HL, Hailun; SY, Shengyang; FQ, Fengqiu; CW, Changwu; YT, Yangting; QY, Qiyang; FK, Fukang. Ctrl, no fertilization; NK, nitrogen and phosphorus inputs; NPK, nitrogen, phosphorus and potassium inputs.