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Data Article

Experimental supporting data on seasonal dynamics of different soil nitrogen pools affected by long-term fertilization regimes

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ABSTRACT

The data presented in this article are related to the research paper entitled "Changes in N supply pathways under different long-term fertilization regimes in Northeast China" [1]. Seasonal dynamics of soil NH_4^+–N, NO_3^-–N, soil microbial biomass nitrogen (N) and fixed NH_4^+ were provided on the basis of a 26-year long-term experiment, including six treatments: no fertilizer (CK), recycled manure (M), N and P fertilizers (NP), P and K fertilizers (PK), N, P and K fertilizers (NPK), and NPK fertilizers with recycled manure (NPKM). The presentation of potential N retention and supply through soil microbial biomass N and fixed NH_4^+ pools at different growth stages is helpful for comparing the effects of different N pools on soil N transformation and assessing synchronies between crop N demand and soil N supply through different N pools.

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Specifications Table

Subject	Agricultural Science
Specific subject area	The subject area focuses on soil N retention and supply in relation to the long-term different fertilization regimes
Type of data	Tables
How data were acquired	Soil total N was determined with an Elementary elementar analyzer (Vario EL III, Germany)
Data format	Raw and Analyzed data
Parameters for data collection	The area of each treatment (main plot) was 486 m^2 with three replicates (subplot 162 m^2).Maize monoculture has been performed. Soil samples from the plow layer (0–15 cm) in each subplot were collected at eleven growth stages. Five cores were randomly sampled from each subplot and then mixed thoroughly.
Description of data collection	The data on soil mineral N (NH_4^+–N and NO_3^-–N) was determined through steam distillation after MgO and Devarda's alloy were added, respectively, and the extraction was extracted from fresh soil with 2 M KCl [2]. The data on fixed $NH_4^+$was mesured in accordance with the method suggested by Silva and Bremner [3]. The data on soil microbial biomass N was determined by chloroform ($CHCl_3$) fumigation-extraction method [4].
Data source location	Institution:The Shenyang Experimental Station of Institute of Applied Ecology, Chinese Academy of Sciences City/Town/Region: Shenyang City/Liaoning Province Country: China Latitude and longitude (and GPS coordinates) for collected samples/data:42°32′N, 123°23′E
Data accessibility	With the article
Related research article	Author's name: Qiang Ma, Shuailin Li, Zhiqiang Xu, Shaobo Fan, Zhuqing Xia, Changrui Zhou, Mengmeng Zhu, Wantai Yu Title: Changes in N supply pathways under different long-term fertilization regimes in Northeast China Journal: Soil & Tillage Research https://doi.org/10.1016/j.still.2020.104609

Value of the Data

- Seasonal dynamics of different soil N pools were provided to explore the impacts of long-term fertilization on soil N transformation
- These data are useful for agricultural and soil scientists who study soil N transformation, and also crop producer who want to increase N use efficiency and reduce N losses.
- Clarification of the pathways of N retention and supply can provide helpful implications for specifically optimizing N fertilizer management and enhancing the synchrony between crop N demand and soil N supply.

1. Data Description

Seasonal dynamics of soil NH_4^+–N, NO_3^-–N, soil microbial biomass nitrogen (N, SMBN) and fixed NH_4^+ were monitored in 2015 on the basis of a 26-year experiment, including six treatments: no fertilizer (CK), recycled manure (M), N and P fertilizers (NP), P and K fertilizers (PK), N, P and K fertilizers (NPK), and NPK fertilizers with recycled manure (NPKM). Soil samples were collected at 11 maize growth stages. The potentials of N retention and supply through SMBN and fixed NH_4^+ pools at different growth stages were calculated with difference method and given in Tables 1 and 2. The process of microbial immobilization was primarily observed from 27/4 (day/month, the same as in other instances) to 23/6, whereas the process of mineralization mainly occured from 23/6 to 29/9 (Table 1). NH_4^+ was principally fixed by soil minerals from 23/6 to 3/7 in the M and NP treatments, and the fixation of NH_4^+ was primarily obtained from

Table 1
Potentials of N retention and supply through soil microbial biomass N pool in different crop growth periods (kg ha^{-1}).

Treatments	Immobilization			Mineralization		
	27/4–23/6	23/6–3/7	Total	27/4–23/6	23/6–29/9	Total
CK	35.1 a	0.0 a	35.1 a	0.0 a	37.5 ab	37.5 a
M	49.9 b	0.0 a	49.9 b	0.0 a	68.9 c	68.9 b
NP	33.5 a	7.9 b	41.4 ab	6.0 b	30.4 a	36.4 a
NPK	23.8 a	24.9 c	48.7 ab	0.0 a	44.6 b	44.6 a
NPK+*M*	28.8 a	9.0 b	37.8 ab	0.0 a	42.5 b	42.5 a
PK	36.2 a	0.0 a	36.2 a	0.0 a	45.0 b	45.0 a

Different letters within each column indicate significant differences according to Duncan's multiple-range test ($P < 0.05$).

Table 2
Potentials of N retention and supply through fixed NH_4^+ pool in different crop growth periods (kg ha^{-1}).

Treatments	Fixation			Release		
	27/4–23/6	23/6–3/7	Total	27/4–23/6	23/6–29/9	Total
CK	5.8 a	5.2 a	11.0 a	0.0 a	16.1a	16.1a
M	4.2 a	23.6 b	27.8 a	0.0 a	37.9b	37.9b
NP	4.7 a	46.1 c	50.8 b	8.3 b	49.5b	57.8c
NPK	48.2 b	46.0 c	94.2 c	0.0 a	84.0c	84.0d
NPK+*M*	73.8 c	42.3 c	116.1 d	0.0 a	92.3c	92.3d
PK	19.5 a	3.0 a	22.5 a	0.0 a	19.7a	19.7a

Different letters within each column indicate significant differences according to Duncan's multiple-range test ($P < 0.05$).

Table 3
Clay mineral composition of test soil (< 2 μm,%).

Smectite	Vermiculite	Hydromica	Kaolinite	Chlorite	Quartz	Feldspars
12	17	21	24	23	1	2

27/4 to 23/6 in the NPK+*M* and PK treatments. In the CK and NPK treatments, the amounts of NH_4^+ fixed by soil minerals were similar at different stages. The process of fixed NH_4^+release primarily occured from 23/6 to 29/9 (Table 2).

2. Experimental design, materials, and methods

2.1. Site description

The long-term experiment has been conducted since 1990 in the Shenyang Experimental Station of the Chinese Academy of Sciences, Liaoning Province, Northeast China (42°32′N, 123°23′E). The mean annual rainfall over the period of the experiment is 680 mm with a mean annual temperature of 7.5 °C. The test soil is Alfisol, which is the primary soil type for agricultural production in the region, with 2:1 clay mineral contents (Table 3).

2.2. Experimental design

The experiment had a complete block design with 12 treatments. Six treatments were selected from 12 treatments, i.e., (1) CK (no fertilizer), (2) M (recycled manure), (3) NP (inorganic N and P fertilizers), (4) NPK (inorganic N, P, and K fertilizers), (5) NPKM (combined application of inorganic N, P, and K fertilizers and recycled manure), and (6) PK (inorganic P and K). The area of each treatment (main plot) was 486 m^2 with three replicates (subplot 162 m^2). From

1990 to 2011, a three-course rotation was conducted (soybean [*Glycine* max L.] and 2 × maize [*Zea mays* L.]), and each subplot was cultivated in accordance with a soybean–maize–maize sequence. The experimental design was similar to the Broadbalk long-term experiment in Rothamsted Experimental Station [5]. The three-course rotation guaranteed the appearances of different crops in every year. As such, the responses of different crops to environmental changes were monitored and compared. Maize monoculture has been performed with three replicates (subplot) since 2012. The maize population was 55,500 plants per hectare.

Nitrogen, P, and K fertilizers were applied in the forms of urea, triple superphosphate, and potassium chloride, respectively. The application rates of N, P, and K fertilizers for maize were 150 kg N ha^{-1}, 17.9–25 kg P ha^{-1}(17.9 kg P ha^{-1} from 1990 to 1996 and 25 kg P ha^{-1} since 1997), and 60 kg K ha^{-1}, respectively. Nitrogen was applied in two splits: 40 kg N $ha^{-1}$was basally applied at sowing, and the remaining 110 kg N $ha^{-1}$was top dressed at the stem-elongation stage. Nitrogen fertilizer for soybean was basally applied at 25 kg N ha^{-1}, and the application rates of P and K fertilizers for soybean were the same as those for maize. All P and K fertilizers were basally applied regardless of crop type.

The organic manure was derived from nutrient recycling under the corresponding treatment, and this was the highlight of this long-term experiment. Given that 80% of the population lived in the countryside in China at the beginning of this long-term experiment, nutrients in the corresponding percent of grain yield (80%) could be recycled in the countryside and returned to the field, avoiding the blindness of the application rate of organic manure and representing the real contribution of nutrient cycling to agricultural systems when the quantity of organic manure resources was considered at a regional scale. 80% of the early harvested seeds under the M and NPKM treatments were fed to two experimental pigs in two pens. No exogenous feedstuff was added to the pigs' diets. A total of 50% of maize stalk and 100% of the soybean straw originating from the corresponding treatment were ground and used as litter. After the feed was consumed, all of the excreta and litter of each pig were collected and composted to produce recycled organic manure in two piles. The organic manure was returned to the initial treatment in the following spring prior to sowing, and a one-to-one correspondence between each treatment and the experimental pig was conducted. A nutrient recycling process that consisted of "fertilization–crop uptake–feeding–composting–returning to fields" was completed. Therefore, the application rates of the recycled manure varied in accordance with different treatments and different years because the quantity of recycled manure relied on crop yield under the corresponding treatment in the last year. From 1991 to 2015, the average annual application rates of recycled manure were 1.47 and 2.14 t ha^{-1} (equal to 44.5 and 60.6 kg N ha^{-1}), under the M and NPKM treatments, respectively. In 2015, the corresponding values were 1.56 and 2.29 t ha^{-1} (50.9 and 73.1 kg N ha^{-1}), respectively.

2.3. Soil sampling and chemical analysis

In 2015, soil samples from the plow layer (0–15 cm) in each subplot were collected on 27/4 (prior to seeding and basal dressing), 8/5 (after seeding and basal dressing), 15/5 (prior to emergence), 25/5 (seedling), 23/6 (jointing and prior to top-dressing), 29/6 (after top-dressing), 3/7, 23/7 (tasseling), 29/8 (filling), 29/9 (maturity), and 26/10 (after harvest). Five cores were randomly sampled from each subplot and then mixed thoroughly.

Fresh soil was extracted with 2 M KCl, and mineral N (NH_4^+–N and NO_3^-–N) was determined through steam distillation after MgO and Devarda's alloy were added [2]. After extraction, the residual soil was air dried for the determination of fixed NH_4^+ in accordance with the method suggested by Silva and Bremner [3]. Chloroform ($CHCl_3$) fumigation-extraction method was employed to estimate the amount of SMBN by using the equation: $SMBN = E_N/K_{EN}$, where E_N is the N extracted by 0.5 M K_2SO_4 from fumigated soil minus that extracted from non-fumigated soil, and K_{EN} is the conversion factor for SMBN (0.54) [4]. Soil C and N were determined with an Elementary Vario EL III elemental analyzer. Standard techniques were used to measure soil-available N (alkaline hydrolyzation method) [6], available P (0.5 mol L^{-1} $NaHCO_3$ at pH 8.5) [7], exchangeable K (1 mol L^{-1} NH_4OAc at pH 7) [8], and pH (soil:water ratio of 1:2.5) [9]. The soil properties under different treatments in spring in 2015 are presented in Ma et al. [1].

2.4. Data analysis

2.4.1. Assessing the potentials of N retention and supply

The potentials of N retention by SMBN or the fixed NH_4^+ pool were the sum of the increases in SMBN or fixed NH_4^+ from 27/4 to 23/6 and increases from 23/6 to 3/7, on the basis of the stages of the basal application and top-dressing of N fertilizer. The increase in SMBN or the fixed NH_4^+ pool over a certain period was determined as the difference between the maximum and minimum (SMBN) or initial value on 27/4 (fixed NH_4^+) in the corresponding period. For example, the increase in SMBN in the first period (27/4–23/6) under the NP treatment was 18.6 mg kg^{-1} (equivalent to 33.5 kg ha^{-1}, bulk density was calculated as 1.2 g cm^{-3}), and the corresponding value was 4.4 mg kg^{-1} (7.9 kg ha^{-1}) in the second period (23/6–3/7) (Table 1). Therefore, the potential of N retention by SMBN was 23.0 mg kg^{-1} (41.4 kg ha^{-1}) under the NP treatment in the maize growth season. The potentials of the N supply of these two N pools in two periods, i.e., the first period from 27/4 to 23/6 and the second period from 23/6 to 29/9, were also calculated. The potential of N supply was presented as the difference between the maximum in the period and the value on the last sampling day in the corresponding period. For example, the potential N supplies of the fixed NH_4^+ under the NP treatment, i.e., the release of fixed NH_4^+, in the first and second periods were 4.6 mg kg^{-1} (8.3 kg ha^{-1}) and 27.5 mg kg^{-1} (49.5 kg ha^{-1}), respectively (Table 2). The potential N supply of fixed NH_4^+ was 32.1 mg kg^{-1} (57.8 kg ha^{-1}). When the potential N supply of SMBN or fixed NH_4^+ was negative in a period, it was set to zero.

2.4.2. Statistical analysis

The data of different soil N pools under different treatments at various growth stages were subjected to one-way ANOVA followed by Duncan's multiple comparisons by using SPSS 20.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material, i.e. the raw data, associated with this article can be found, in the online version, at doi:10.1016/j.dib.2020.106005.

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