Dynamics of ryegrass P in red soils*

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Abstract An investigation on the dynamics of transformation of P from ^{32}P-labelled ryegrass in red soils was conducted in laboratory. The results showed that the rapid increase in flush ^{32}P related with biomass P was accompanied with the decrease in extractable ^{32}P on the first 3 d of incubation in both sandy and clayey soils, and afterwards, it displayed great fluctuation in sandy soil, but had little fluctuation in clayey soil during 3~20 d of incubation. At the later stage of incubation, the increase in extractable ^{32}P was accompanied with decrease in flush ^{32}P. The opposite changes in content of extractable ^{32}P and flush ^{32}P suggested transformation of ryegrass P was closely related to its utilization and its release from microorganisms in red soils. It can be concluded that addition of organic matter accelerated the release of soil native P according to the changes in the extractable soil P during incubation.

Keywords ^{32}P-labelled ryegrass, Extractable P, Microbial transformation of ryegrass P, Red soils

1 Introduction

Numerous studies have been conducted to investigate turnover of N from ^{15}N-labelled organic matter in various soils[1~5], but only little information has been reported on mineralization of P from ^{32}P-labelled plant materials added to soil.[6,7] Hundal *et al* determined the mineralization of P from ^{32}P-labelled plant material of cowpea added to Fatehpur sand and found that plant residue added to soil released inorganic P through mineralization.[6] In this study, we investigated the dynamics of inorganic P and biomass P after ^{32}P-labelled ryegrass was added to two types of red soils.

2 Materials and method

2.1 Soils

Two types of red soils, sandy and clayey soils were selected in the study. The soil samples were taken from the surface layer of fallow land in Longyou County of Zhejiang Province. The air-dried soils were passed through a sieve of 20 mesh. The basic properties of the soils were listed in Table 1.

Table 1 Properties of the soils

Item	pH (H_2O)	Available P/ mg·kg^{-1}	OM/ g·kg^{-1}	Total N/ mg·kg^{-1}	Exchangeability/cmol·kg^{-1}				
					K^+	Na^+	Ca^{++}	Mg^{++}	CEC
Clayey	4.16	3.21	8.4	340	0.19	0.02	0.69	0.30	6.62
Sandy	4.55	2.71	6.5	280	0.06	0.02	0.38	0.11	4.53

2.2 Labelling ryegrass

Ryegrass was labelled uniformly by growing it in gravel culture system in which cultural solution contained ^{32}P-NaH_2PO_4. Phosphorus content of the ryegrass was 0.625% measured by colorimetric analysis and the specific activity of ^{32}P was 4174 cpm/μg P measured by Cherenkov counting method with Packard 1900 TR scintillation counter (USA) at the time of being mixed with the soils.

2.3 Incubation of soil with labelled ryegrass

Air-dried soils were adjusted to 40% water holding capacity (WHC), pre-incubated at 25°C for 10 d, mixed with labelled ryegrass (<40 mesh) at the addition rate of 4 percent

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based on dry weight, then the mixtures were adjusted to 60% WHC, incubated at 25°C, kept the samples in the given WHC by weighing the flask with the sample and supplementing distilled water periodically.

2.4 Sampling and analyzing

The samples were taken to analyze extractable P with 0.5 mol/L $NaHCO_3$ (pH8.5) and flush P (increase in extractable after fumigating with CH_3Cl_3) on intervals of 0, 1, 3, 6, 9, 12, 15, 20, 30, 45, 60 d of incubation. 0.5 mol/L $NaHCO_3$-extracts from both fumigated and unfumigated samples were measured by the Cherenkov method for ^{32}P and by colorimetric analysis for total P content. The results were corrected with decay of radioactivities and recoveries, and expressed as μg P/(g air-dried soil).

3 Results and discussion

3.1 Dynamics of extractable ^{32}P

A high content of $NaHCO_3$-extractable ^{32}P which accounted for 83.57% of total ^{32}P was observed in the added ryegrass. The addition rate of ryegrass-P (labelled) was 250μg/g dried soil containing 208.9μg of extractable P. The amount of ^{32}P extracted from samples immediately after ryegrass was mixed with soil was 115.37 μg/g for the sandy and 100.03μg/g for the clayey, which indicated that fixation of ^{32}P by soil occurred during the mixing of the soil with ryegrass and the fixation rate for sand and clayey were 44.77% and 52.12%, respectively.

Extractable ^{32}P in both sandy and clayey soils declined sharply during the first 3 d of incubation and then fluctuated during 3~20 d of incubation with two peaks on the 6 th day and the 15 th day for the sandy, and 6 th day and 12 th day for the clayey soil. During 20~60 d of incubation the amount of extractable ^{32}P increased with incubation time for both soils, but it fluctuated in the sandy soil. The concentration of extractable ^{32}P in the sandy soil was always higher than that in the clayey soil at all sampling time (Figs.1,2).

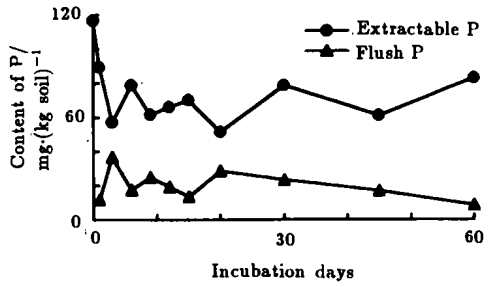

Fig.1 Changes in contents of extractable P and flush P from ryegrass in sand soil

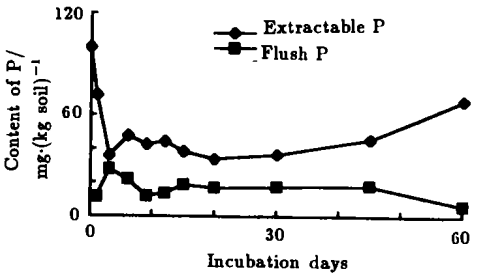

Fig.2 Changes in contents of extractable P and flush P from ryegrass in clayey red soil

3.2 Dynamics of incorporation of ^{32}P to biomass

Changes in flush ^{32}P (increase in 0.5 mol/L $NaHCO_3$-extractable ^{32}P of samples after fumigating) with incubation time reflected the dynamics of incorporation of ryegrass P to microbial biomass.

Considering effects of fixation of ^{32}P by soils on flush ^{32}P, a supplementary experiment was conducted. Inorganic ^{32}P (^{32}P-KH_2PO_4) corresponding to the amount of extractable ^{32}P in ryegrass was added to check soils, mixed thoroughly and incubated at 25°C, samples were taken to measure the extractable ^{32}P every day. Table 2 shows that fixation of ^{32}P by soils occurred within 2 d after it was added to the soils. The extractable ^{32}P was also subjected to fixation by the soils. So the flush ^{32}P for samples of one day of incubation should be corrected with recoveries, because recoveries of extractable ^{32}P

for the control samples which were extracted on one day after incubation differed from fumigation samples which were extracted on 2 d after incubation. Thus the flush ^{32}P on one day of incubation reached more than 11 μg/g, then rapidly increased and reached the highest value on 3 d of incubation in both soils, afterwards, the values of flush ^{32}P in the sandy fluctuated with peaks on the 9 th d and the 20 th d and declined linearly from 20 d to 60 d of incubation (Fig.1). While the values of flush ^{32}P in the clayey soil declined after 3 d and increased between the 9 th d and the 15 th d of incubation, and then displayed a flat up to the 45 th d and declined after 45 d of incubation (Fig.2).

Table 2 Recoveries of inorganic ^{32}P added to check red soils (%)

Soils	Incubation days				
	0	1	2	3	4
Sand	65.01	58.49	51.11	49.23	50.23
Clayey	51.52	42.86	33.61	33.62	32.33

The changes in flush ^{32}P were just opposite to those of extractable ^{32}P. The results suggested that transformation of ryegrass P was closely related to its utilization and its release from microorganisms in red soils. The contents of extractable ^{32}P and flush ^{32}P in the sandy soil were higher than those in the clayey soil, this may be attributed to the difference in the fixation of ^{32}P by soils and microorganisms activities between two soils (see Figs.1,2).

Table 3 Extractable soil P after different time incubation with ryegrass (μg P/g air-dried soil)

Soils	Incubation days										
	0	1	3	6	9	12	15	20	30	45	60
Sand	2.71	3.00	55.75	45.54	30.98	51.08	71.98	71.24	81.16	78.51	44.59
		±0.09	±0.62	±0.92	±1.86	±0.79	±4.83	±2.91	±3.86	±2.82	±1.58
Clayey	3.21	3.56	51.24	42.06	37.56	32.56	31.55	31.28	33.98	41.28	64.75
		±0.11	±0.83	±0.66	±1.02	±1.28	±1.88	±1.78	±1.05	±1.07	±3.3.

3.3 Changes in inorganic P from soil during incubation

Inorganic P from soil could be calculated by subtracting inorganic ^{32}P from total inorganic P in extracts. Inorganic P from soil on the first day of incubation was a little higher than the original available P, but it increased sharply on the first 3 d of incubation for both soils, the values of inorganic P from soil in the sandy soil decreased within 9 d followed by an increase to the highest value on the 30 th d and significantly declined after 45 d. While those in the clayey revealed a decrease after 3 d followed by a flat during 12~ 30 d and then increased after 30 d (see Table 3). The result explained that addition of organic matter promoted the release of the soil native P.

In addition, extractable ^{32}P with 0.1 mol/L NaOH from samples after being extracted with 0.5 mol/L $NaHCO_3$ was also measured on the 20, 30 and 60 d of incubation. The results showed that most of it was in the form of inorganic ^{32}P, only a small amount of ryegrass P (<5% of applied P) was incorporated into organic constituents.

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