Uptake of phosphorus by ryegrass and effect of adding organic matter on inorganic P absorption in red soil*

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Abstract ^{32}P-labelled KH_2PO_4 with or without unlabelled ryegrass and ^{32}P-labelled ryegrass with unlabelled KH_2PO_4 were respectively applied to red soil, and ryegrass was grown in the fertilized soil and harvested one month after sowing and then the radioactivities and total P content in ryegrass were measured. Results show that addition of organic matter to red soil can significantly stimulate the uptake of P by ryegrass seedlings from inorganic P applied to red soil; absorption of P from inorganic source is much greater than that from organic source; at the same application level of P, larger proportion of P derived from labelled inorganic phosphate was distributed in shoots than that from the labelled ryegrass.
Keywords ^{32}P tracer method, Phosphorus absorption, Red soil, Ryegrass

1 Introduction

Phosphorus in plant materials added to soil can be mineralized into inorganic forms through microbial activity and becomes available to growing plants[1]. Hundal[2] studied mineralization of phosphorus from ^{32}P-labelled cowpea residue added to soil in the presence of growing maize and found that the presence of growing maize plant led to a significant increase in net P mineralization from the labelled material. Many studies have been made to understand the uptake of nitrogen from plant materials added to soil and effects of incorporation of plant residues to soil on uptake of nitrogen from fertilizer by growing crops.[3~8] However, there were few attempts to investigate the effects of addition of plant materials on uptake of phosphorus from inorganic source by plants. This paper is to investigate the uptake of phosphorus from labelled ryegrass by growing ryegrass in red soil and to compare the uptake of fertilizer P applied to red soil by growing ryegrass in the presence of ryegrass plant material with that in the absence of ryegrass plant material.

2 Materials and method

The test soil was taken from the surface layer of fallow land in Longyou County of Zhejiang Province. The basic properties of the soil were listed in Table 1. 250g of each air-dried and screened red clayey soil (<20 meshes) was adjusted to 40% of water holding capacity (WHC) and mixed either with ^{32}P-labelled ryegrass (<40 meshes, 2.61×10^7 cpm/g) plus KH_2PO_4 or with KH_2PO_4 plus ^{32}P-NaH_2PO_4 in the presence or absence of unlabelled ryegrass (<40 meshes) according to the designed treatments (Table 2).

The mixtures were put into 250 ml plastic cups with three holes and sponge at the bottom. The cups were placed in culture dishes, a certain amount of water was added to the dishes so that soil could absorb water through holes at the bottom of the cups. 100 ryegrass seeds were sowed on the surface of soil, and covered with 10g air-dried soil and then 2 ml distilled water was added to the cups on 12 d after treatments.

0.1g urea and a given amount of KCl were applied to each cup on 17 d after seedling emergence. One month after sowing, the ryegrass shoots were cut, the roots were separated from soil and washed to remove the adherent soil. The dried and ground samples were digested with H_2SO_4-H_2O_2, radioactivities in the digests were measured by Cherenkov method with liquid scintillation counter (Packard 1900TR,

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USA). Total P in the digests was analyzed with colorimeter. The total radioactivities in ryegrass were calculated by the following equation:

$$Total\ radioactivities = \frac{a \cdot V_t \cdot W_t}{V_m \cdot W_d} \quad (1)$$

where a is counts per minute (cpm)of samples measured, V_m the volume of samples measured(ml), W_d the mass of samples digested (g), V_t the volume of digests(ml), W_t the total mass of shoots or roots (g).

The fraction of P in ryegrass derived from labelled source (PDFL) was the ratio between specific activities of sample (cpm in sample measured/μg P in sample) and specific activities of labelled source. With the fractions (PDFL), the amount of P in ryegrass from both labelled and unlabelled sources could be calculated:

$$Amount\ of\ P\ from\ labelled\ sources = \text{PDFL} \times total\ P \quad (2)$$

$$Amount\ of\ P\ from\ unlabelled\ sources = (1 - \text{PDFL}) \times total\ P \quad (3)$$

Table 1 Properties of the soil

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
Red clayey	4.16	3.21	8.4	340	0.19	0.02	0.69	0.30	6.62

Table 2 Different treatments for P uptakes from organic and inorgainic sources

No	Treatment	KH_2PO_4/ mg	^{32}P-$NaH_2PO_4^d$/ ml	Ryegrass/ g	^{32}P-ryegrass/ g	$(NH_2)_2CO$/ mg
T_1	L^aIP^b	137.2	3.28	0	0	186
T_2	LIP+OM^c	137.2	3.28	5	0	61
T_3	1/2(LOM+IP)	68.6	0	0	2.5	93
T_4	1/2(LIP+OM)	68.6	1.64	2.5	0	124

a: L represents labelled source, b: IP represents inorganic phosphorus, c: OM represents organic matter, d: specific activity of ^{32}P-NaH_2PO_4 solution was 1.14 MBq/ml at the application time.

3 Results and discussion

3.1 Fraction and distribution of P in ryegrass derived from labelled sources

The fraction and distribution of P in ryegrass derived from inorganic or organic source were shown in Fig.1 and Fig.2, respectively. The fraction of P in both roots and shoots of ryegrass from labelled ryegrass was much lower than from labelled phosphate at the same application level of P. Combining application of inorganic phosphate with unlabelled ryegrass increased the fraction of P in ryegrass from labelled phosphate by 2-3 times compared with the application of inorganic phosphate alone. As can be seen from Fig.2 , larger proportion of P derived from labelled inorganic phosphate appeared in shoots than that from the labelled ryegrass, and addition of unlabelled ryegrass increased the distribution of labelled inorganic phosphate in the shoots of ryegrass significantly. The results showed that P in phosphate was more favorable to be uptaken by ryegrass compared with P in ryegrass added to the soil and that addition of unlabelled ryegrass accelerated the absorption and transportation of phosphate by ryegrass in red soil.

3.2 Uptake and utilization of P from labelled sources

The total absorbed labelled P in T_1 (absence of ryegrass) and T_2 (presence of ryegrass) exhibited much larger difference than that derived from corresponding inorganic sources, consequently utilization of labelled inorganic P by ryegrass revealed a great disparity between the two treatments (Table 3). The result indicated that absorption and utilization of applied inorganic P by ryegrass seedlings increased obviously by adding organic matter. When the

amount of inorganic P and ryegrass applied was reduced to half (T_3 and T_4), the utilization of inorganic P by ryegrass (T_4) was almost the same as treatment T_2, but the utilization of P from organic matter (T_3) was much lower than that from inorganic P.

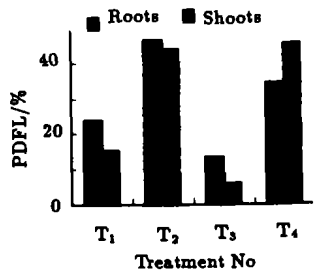

Fig.1 Percentage of P in ryegrass derived from labelled source

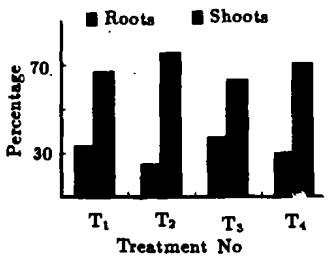

Fig.2 Distribution of P in ryegrass from labelled sources

Table 3 Uptake and utilization of P from labelled sources

Treatment	P from labelled sources/mg			Utilization of labelled P/%		
No	Roots	Shoots	Whole	Roots	Shoots	Whole
T_1	0.188±0.017	0.379±0.083	0.567±0.100	0.60±0.05	1.21±0.27	1.82±0.32
T_2	0.547±0.044	1.672±0.121	2.218±0.157	1.75±0.14	5.35±0.50	7.10±0.50
T_3	0.082±0.014	0.140±0.018	0.222±0.030	0.53±0.10	0.89±0.11	1.42±0.21
T_4	0.353±0.015	0.837±0.158	1.191±0.172	2.21±0.10	5.35±1.01	7.57±1.05
$LSD_{0.05}$	0.026	0.231	0.274	0.632	1.164	1.329
$LSD_{0.01}$	0.085	0.332	0.394	0.908	1.670	1.910

Table 4 Uptake of P from unlabelled sources mg

Treatment No	Roots	Shoots	Whole
T_1	0.560±0.039	2.025±0.238	2.625±0.270
T_2	0.643±0.162	2.116±0.038	2.766±0.188
T_3	0.525±0.071	2.259±0.074	2.784±0.144
T_4	0.678±0.049	1.001±0.127	1.692±0.083
$LSD_{0.05}$	0.089	0.594	0.396
$LSD_{0.01}$	0.291	1.930	0.569

3.3 Uptake of P from unlabelled sources

It can also be found from Table 4 that the amount of P derived from unlabelled sources in the treatment amended with organic matter was slightly higher than that in the treatment without organic matter. At the amending rate of 125 mg·P·kg^{-1} soil, this slight increase may be attributed to the organic matter amended. However, the amount of P uptaken from unlabelled source by shoots with labelled inorganic source exhibited a much larger decrease (by more than 50%) than that with labelled organic source. It further confirms that uptake of P from inorganic source by ryegrass seedlings was much greater than that from organic source under the same conditions.

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