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Validity for using plant xylem sap to evaluate inorganic nutrient availability in soil

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Abstract

Various soil extraction methods are commonly used method for evaluating the available nutrient content in soil. Although these methods have several advantages they also have some problems, including the difficulty of simultaneous evaluation of multiple components. To overcome these problems, we have proposed the "xylem sap method", which uses the nutrient concentrations in xylem sap of sponge gourd (*Luffa cylindrica* Roem) to evaluate the available nutrient contents in soil. When we changed the cation exchange capacity in soil to change cationic nutrient availability without changing the total quantity in the soil, we concluded that the xylem sap method is superior to the extraction method as an indicator of nutrient availability in soil. In this paper we report the potential for using the xylem sap method to evaluate availability of P. Seedlings of sponge gourd were grown in a number of soils, with different P levels in Neubauer pots and the hypocotyls were cut at the fourth-leaf stage. Plastic tubes were placed on the cut ends to collect xylem sap for 24 hours. P and K concentrations in the xylem sap and plant tops, and extracted from soils with a solution composed of calcium lactate, calcium acetate and acetic acid (CAL-method) were analyzed. There was a high correlation between the P and K content in shoots and the concentration in xylem sap. Therefore, we regarded that the xylem sap method has validity for evaluating anionic and cationic nutrient availability in soil.

Introduction

We proposed a xylem sap method as a new way to evaluate nutrient availability in soil instead of the soil extraction methods which are the conventional way Noguchi *et al.*, in press (a)). Nutrient concentrations in xylem sap of *Luffa cylindrica* Roem. seedlings are used as an indicator of nutrient availability in soil. When we changed the cation exchange capacity (CEC) in soil to change cationic nutrient availability, a highly positive correlation was consistently found between the amount of nutrients absorbed by the plants and their concentrations in the xylem sap for every nutrient (Noguchi *et al.*, in press b)). By contrast, the lower correlation was shown for the extraction method with different extractants. We concluded that the xylem sap method is superior to the extraction method as an indicator of nutrient availability in soil. However, the xylem method was not evaluated for anionic nutrients such as phosphorus. In this study we studied the capacity of the xylem method to determine P availability in a range of different soils.

Materials and methods

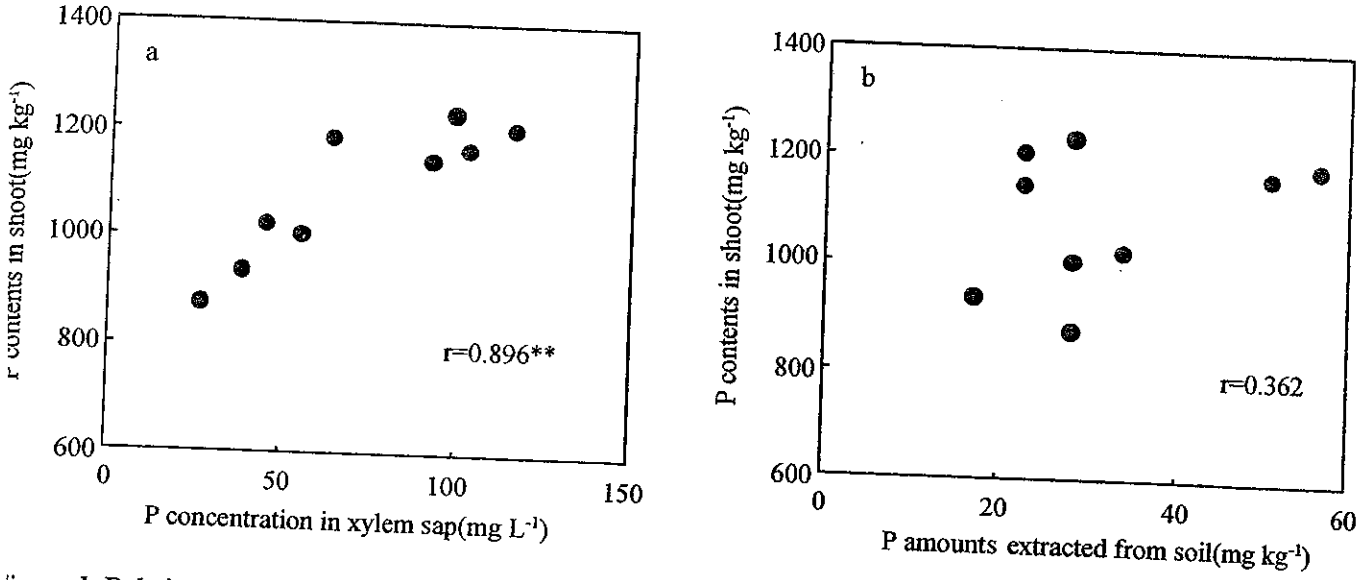
Soils were collected from fields (in Dürnast Experimental station of Technical University Munich, Freising, Germany), which have combination of different application level of phosphorus (0 kg P_2O_5 ha^{-1} y^{-1}, 60 and 90 kg P_2O_5 ha^{-1} y^{-1} superphosphate and 270 kg P_2O_5 ha^{-1} y^{-1} as apatite) and with and without liming. Two hundred fifty grams of soil and the same weight of quartz sand were blended and placed in Neubauer pots. Six seedlings of *L. cylindrica* were transplanted into the pots. After transplantation, another 50 g of quartz sand was added on top of the soil. The seedlings were grown in a growth chamber (25℃), and watered regularly with deionized water to maintain 60% of the maximum water-holding capacity of the soil as measured by pot weight. Three replicate pots were used and seedlings were left to grow up to four-leaf stage (approximately 1 month).

The stem was cut at the hypocotyl below the cotyledons and the part above the cut was removed. One end of a soft plastic tube was fitted over the end of the cut hypocotyl, with the other end inserted into a test tube. Xylem sap was collected continuously for 24 hours, starting in the morning.

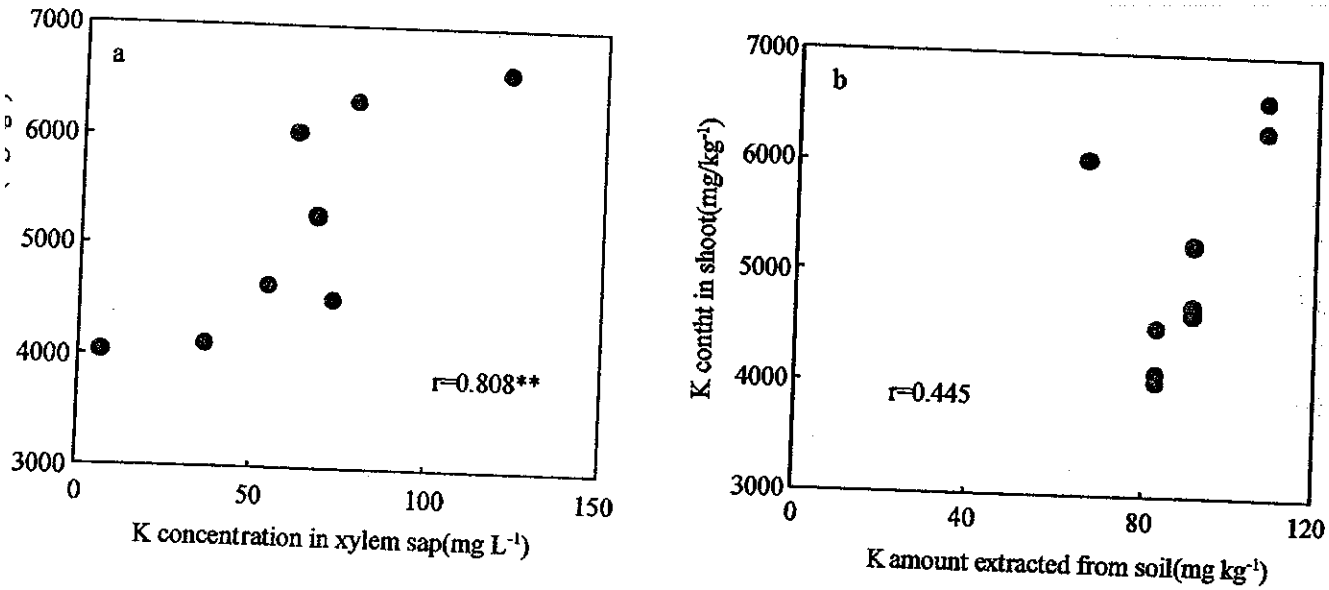
The phosphorus concentration in the removed shoots and the xylem sap were measured. Soil phosphorus was extracted with the CAL-extractant (0.1M calcium lactate-0.1M calcium acetate-0.3M acetic acid, pH 4.1) and was measured (the CAL-method is a common method to evaluate availability of P and K in soils in Germany). The xylem sap method and the CAL-method were compared to evaluate the availability of phosphorus and potassium in soil.

Table 1. Phosphorus content (mg kg^{-1}) in the shoots

P application rate and source (kg P_2O_5 ha^{-1} y^{-1})	Without liming (pH 4.8-5.4)	With liming (pH 6.3-6.4)
0	875	937
60 (superphosphate)	1020	1010
90 (superphosphate)	1170	1180
270 (apatite)	1140	1230



igure 1. Relationship of a P concentration in xylem sap and b amount of it extracted using CAL-extractant ith the content in the plant.



re 2. Relationship of a K concentration in xylem sap and b amount of it extracted using CAL-extractant the content in the plant.

lts and discussion

The P content in shoots increased with increasing ation rate of P_2O_5 to soil until 90 kg ha^{-1} y^{-1} (Table iosphorus content in the shoots grown with the soil zed with 270 kg P_2O_5 ha^{-1} y^{-1} as apatite was similar t with the soil applied with 90 kg P_2O_5 ha^{-1} y^{-1} as hosphate. There was no effect of liming on the P in the shoot.

hosphorus content in the shoots was highly ted with P concentration in the xylem sap (r=0.896, a)), whereas the correlation to CAL-extractable P in l was poor (r=0.362, Fig. 1b)).

good correlation between potassium in the shoots the xylem sap was also found (r=0.808)(Fig. 2).

herefore, we concluded that the xylem sap method used to evaluate the availability cationic and nutrients in soil.

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