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RESEARCH PAPER

Estimation of the pH of soybean rhizoplane, rhizosphere and bulk soil and its effect on availability and uptake of phosphorus in calcareous Vertisols

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Abstract : Vertisols are spread over central and western parts in Madhya Pradesh in India.As the Vertisolsare calcareous and/or alkaline in nature, mobility of P from soil to root surface is carried by diffusion process, and this diffusion rate is quite low i.e. 0.13mm day^{-1} (Jungk 1991). One of the major limitation is thatmany rhizosphere chemical interactions that can be involved in the changes ofP ion concentration in the soil solution and in the replenishment of the depleted soil solution (P buffering capacity)do not taken into account (Darrah, 1993).This prompted us to re-evaluate the P-fertility of Vertisols. In the study an attempt has been made to evaluate the most suitable method for P availability in calcareous Vertisols for crops considering the pH of rhizosphere. By agar plate technique, the pH of rhizoplane and rhizoplane soil was found acidic even though soil pH was7.6. The major portion of inorganic P in Vertisols is associated with Ca (Ca-P), which can be soluble more under acid condition than pH 8.5 of Olsen's condition. The pH of bulk soil, that is unplanted soil which is treated in same way of applied nutrient and water as the planted pots, is 7.9. Soybean crop decreased the pH of rhizosphere and rhizoplane by 7.5and 6.0 respectively. Following the various crops the pH of rhizosphere decreased. Among various crops tested the lowest pH (5.8) of the rhizosphere and rhizoplane -attached soil was noticed in care of Chickpea. In case of pea, maize, sorghum and wheat the pH of rhizosphere and rhizoplane were 7.4 and 6.1, 7.6 and 6.4, 7.5 and 6.4, 7.5 and 6.3, respectively. Decreased pH due to rhizosphere can dissolve the phosphorus from the Calcium and increase the availability of P in Calcareous/ Alkaline soil.

Key Words : pH of soybean, Rhizoplane, Rhizosphere, Bulk soil, Phosphorus in calcareous Vertisols

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INTRODUCTION

Plant uptake of P from soil is a complicated process, in which P moves to the root surface form P pool fixed on soil particles with an extremely small diffusion coefficient of approximately 0.13 mm day^{-1} (Jungk *et al*., 1991). Due to of the small diffusion rate, P uptake by crop species is proportional to the surface area of roots, including root hairs (Itoh and Barber, 1983). Hence, the P absorption by plant roots originates from the rhizosphere, which consists of the soil surrounding the roots at the thickness of approximately 1.0–2.0 mm

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(Youssef and Chino, 1990; Dotaniya and Meena 2015). The pH levels of rhizosphere are often observed to be 1–2 units lower than that of bulk soil because of acidification by root exudates, such as organic acid (Riley and Barber 1971; Gahoonia *et al.,* 1992; Li *et al*., 2007). This indicates that the pH level of vertisols changes from the original alkaline level, between 7.5 and 8.5, to neutral and acidic in rhizosphere, particularly on the rhizoplane and root surface. Thus, root acidification of the rhizosphere in the vertisols could possibly solubilize increased amounts of P from the soil than those estimated by the Olsen method, using an alkaline extractant at pH 8.5. However, few studies have investigated the acidification of the rhizosphere of various crop species grown on vertisols, and compared soil test results using different extractants for an improved accuracy of estimation of available P in vertisols.

Material and Methods

The insitu experiment was conducted in the Net House of AICRP on Salt Affected Soils, College of Agriculture, Indore. To examined acidification in rhizosphere, six different crop species chickpea (*Cicer arietinum*) JG-21, pea (*Pisum sativum*) Arkel, maize (*Zea Mays*) JM-13, soybean (*Glycine max*) JS 95-60, sorghum (*Sorghum vulgare*), wheat (*Triticum aestivum*) JW-7, were grown in different pots. Vertisols soil of western Madhya Pradesh was used in this examination and growing period of crops were two month. For this experiment 1 kg pot^{-1} soil was taken andexamined the pH of the initial soil sample which was 7.8. The essential nutrients were supplied through dilute solution (Hoagland and Arnon, 1950). Blank soil (without crop) was also kept as control in pot for comparison. Rhizosphere soil have roots of crop, which were gently or vigorously shaken to release loosely or more tightly attached soil and remaining soil on the roots after vigorous shaking was considered as rhizoplane-attached soil. These fractions, including the bulk soil, were placed in distilled water and measured the soil pH with the help of HORIBA twin pH meter. To estimatethe pH of root surface, agar plate method as described by Hausslinget*et. al*., 1985 was used.Seeds were sown in paper glass filled with sand. Roots of 12 days old seedlings of different crops were removed carefully without damage and placed on agar plates containing one of the pH indicators *i.e.* Bromcresol purple (pH 5.2 purple- pH 6.8 yellow) or Bromcresol green (pH 3.8 yellow- pH 5.2 blue) or Bromthymol blue (pH 6.0 yellow- pH 7.6 blue) or Methyl red (pH 4.4 red- pH 6.2 yellow).

Results and Discussion

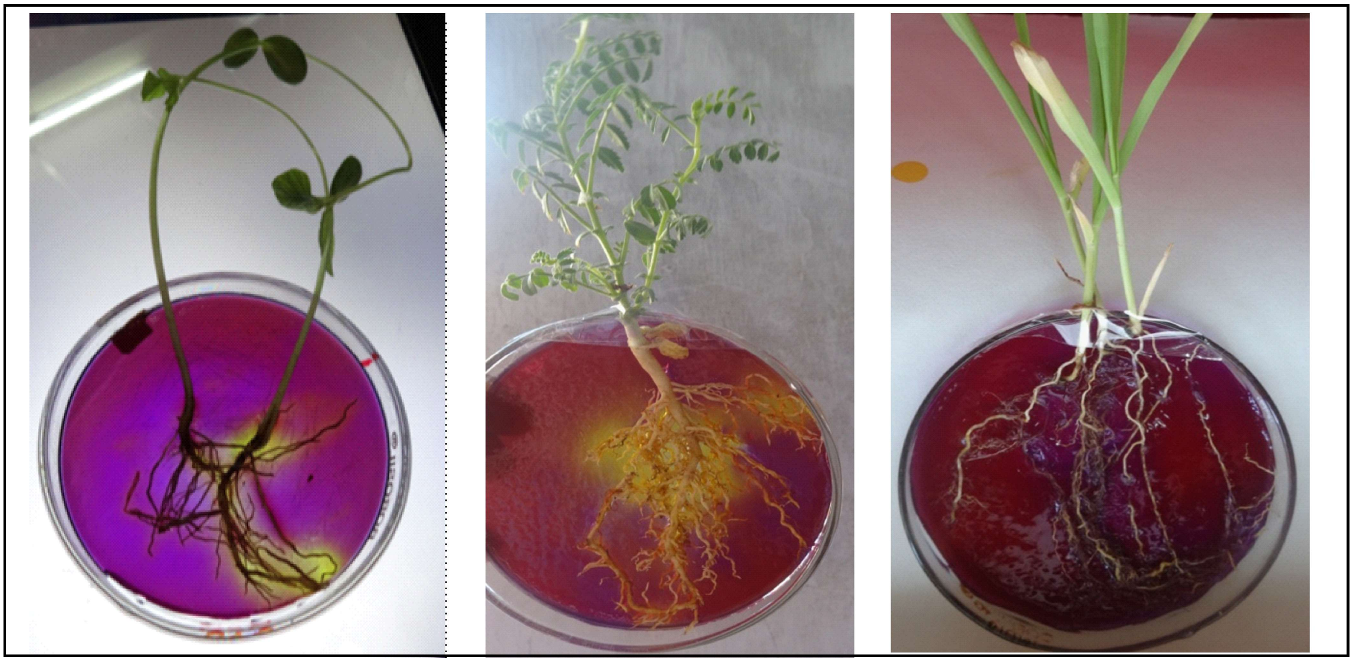
The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

pH of rhizosphere soil and its roots surface (rhizoplane) :

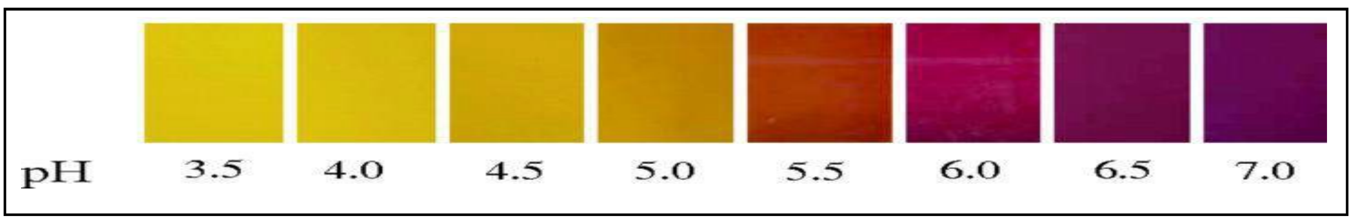
The results shows that acidification of the rhizosphere soil by the roots of various crop species as compared to bulk soil as change in pH was observed. The pH of bulk soil, that is unplanted which is treated in same way of applied nutrient and water as the planted pots, shows no change in pH *i.e.* it remains 7.9. Soybean crop decreases the pH in rhizosphere from 7.9 to 7.5 and in rhizoplane it became 6.0. Following the various crops the pH of rhizosphere shows reduction. Among various crops tested the lowest pH (5.8) in the rhizosphere and rhizoplane -attached soil was noticed in care of Chickpea. In case of pea, maize, sorghum and wheat the pH of rhizosphere and rhizoplane were 7.4 and 6.1, 7.6 and 6.4, 7.5 and 6.4, 7.5 and 6.3, respectively (Table 1). Decreased pH due to rhizosphere can dissolve the phosphorus from the Calcium and increase the availability of P in Calcareous/ Alkaline soil. Decreased pH of soybean roots changed the colorof bromocresol

Table 1: pH of rhizosphere soil, bulk soil and rhizoplane of different crops

Sr. No.	Crop species	pH		
		Bulk soil	Rhizosphere soil	Rhizoplane-attached soil
1.	Soybean	7.9	7.5	6.0
2.	Chickpea	7.9	7.3	5.8
3.	Pea	7.9	7.4	6.1
4.	Maize	7.9	7.6	6.4
5.	Sorghum	7.9	7.5	6.4
6.	Wheat	7.9	7.5	6.3



Soybean **Gram** **Sorghum**



The roots were imbedded for 6 h in agar gel containing a pH indicator (Bromocresol Purple). Yellow indicates acidification and purple indicates alkalization

from purple to yellow,thus rhizoplane pH appeared to be in the range of 6.8-5.2.

The non-response of P application on growth and yield of soybean can be explained on the basis of the pH of rhizhosphere and rhizoplane which is acidic in nature (Table 1). Decreased pH due to rhizosphere can dissolve the phosphorus from the Calcium and increase the availability of P in Calcareous/ Alkaline soil (Ae *et al.,* 1991, Li *et al*., 1997, Neumann *et al.,* 1999). This might be the possible reason for non- response of P application to soybean in these calcareous Vertisols. Further, Many researchers (Riley and Barber, 1971, Gahoonia *et al*., 1992, Li *et al*., 2007) showed that the pH of the rhizosphere soil is 1- 2 unit lower then bulk soil and that difference of pH enhances the solubility of phosphorus from the fixed Ca-P in Vertisols and associated soil (Neumann and Romheld, 1999). Soybean crop decreased the pH in rhizosphere 7.5 and rhizoplane 6.0.Decreased pH of soybean roots changed the colour of bromothymol blue and bromocresol purple, but did not detectably change the colour of the two indicators (methyl red and bromocresol green). Thus rhizoplane pH appeared to be in the range of 6.0-5.2 (Plate 1). The results indicated that the pH values decreased near the roots in soils with a pH of the bulk soil (about 7.0). Changes of pH were as much as 2 units as compared to the bulk soil. Conversely, the rhizosphere pH decreased by about 2 units in soils with a bulk soil pH of 7. A slight decrease in the rhizosphere pH was observed in soils with a bulk soil pH of 8.4. The ability of soybean roots to influence the pH was larger than that of barley.

Conclusion:

These results also agree with the findings of Neumann and Romheld (1999) who reported that some plant species/genotypes release protons into the soil to acidify the rhizosphere condition to enhance P uptake from acid-soluble Ca phosphate. Following the various crops taken under study shows reduction in the pH of rhizosphere.Decreased pH of rhizosphere can dissolve the phosphorus from the Calcium-P and increase the availability of P in Calcareous/ Alkaline soil.On the basis of Agar plate method the rhizoplane pH of soybean appeared to be in the range of 6.0-5.2. Though the soils calcareous alkaline even than the pH of root surface was below 5.5 and in attached soil it might also be lower.

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