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Quantification and correlation of vesicular-arbuscular mycorrhizal propagules with soil properties of some mollisols of northern India

Abstract The populations of vesicular-arbuscular mycorrhizae (VAM) propagules by the most probable number method in some mollisols and their correlations with some important soil properties were determined. On average, the six soils, Phoolbagh clay loam, Beni silty clay loam, Haldi loam, Nagla loam, Khamia sandy loam and Patherchatta sandy loam contained 4.9, 4.0, 7.9, 7.9, 3.3 and 13.0 propagules/g soil, respectively, i.e. none of the soils was found to be high in VAM. The size of the VAM population was compared to soil properties such as pH, organic carbon, sand content, available phosphorus and available potassium, cation-exchange capacity, silt and clay contents. A significant positive correlation ($r=0.586$) was only found with available soil phosphorus ($P<0.05$) and a significant negative correlation ($r=-0.555$) with soil clay content ($P<0.05$).

Key words Vesicular-arbuscular mycorrhizae Population · Correlation · Soil properties · Mollisol

Introduction

In soil, propagules of vesicular-arbuscular mycorrhizal (VAM) fungi may be present as chlamydospores or azygospores, soil-borne vesicles and mycelium or infected root pieces. Under optimal growth conditions, soil propagules (also termed mixed inoculum) have been shown to increase root colonization, nutrient uptake, plant growth and crop yields (Singh 1983). Soils vary in the size of the VAM population (Daniels and Skipper 1982), and relationship seems to exist between the size of the VAM population and particular soil properties (Vyas and Srivastava 1987; Hiremath et al. 1990). The objective of the present investigation was to determine the VAM populations (in terms of propagules) of some mollisols and to correlate them with their some important physical and chemical soil properties.

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Materials and methods

Soils

Surface (0–15 cm) soil samples representing the known soil series (Deshpande et al. 1971) of the farm of G. B. Pant University of Agriculture and Technology, Pantnagar District of Nainital, India were used. After collection, samples were dried in air, processed and passed through a 2-mm sieve. Physico-chemical properties of the soils, such as pH, organic carbon, cation-exchange capacity (CEC), available phosphorus, available potassium, sand, silt and clay contents, were determined using standard methods.

Determination of VAM propagules

The number of vesicular-arbuscular mycorrhizal propagules was determined by the most probable number (MPN) method as described by Porter (1979) with the following details. The soil of each soil series was diluted tenfold using sterilized fine-grade river bed sand containing plant nutrients (mg/kg) KH_2PO_4 35.5, K_2SO_4 71.8, $CaCl_2$ 71.0, $CuSO_4 \cdot 5H_2O$ 2.13, $ZnSO_4 \cdot 7H_2O$ 5.0, $MnSO_4 \cdot H_2O$ 9.9, $CaSO_4 \cdot H_2O$ 0.4, $Na_2MoO_4 \cdot 2H_2O$ 0.2, H_3BO_3 0.7, $MgSO_4 \cdot 7H_2O$ 19.9, $FeSO_4 \cdot 7H_2O$ 12.4, urea 108.0. Dilutions up to 10^{-4} were prepared by mixing soil and sand in surface-sterilized polythene bags in a sterilized inoculation room. Aliquots (200 g) of sand of each dilution was filled in sterilized celluloid cups (7 cm × 8 cm). Each dilution was replicated five times. Five celluloid cups were filled with only sterilized sand to serve as uninoculated controls. Seeds of Mung bean (*Vigna radiata* L. cv. PS-16) were surface sterilized by rinsing in 90% ethyl alcohol and suspension in 0.2% acidified mercuric chloride solution for 3–4 min. After washing several times with sterilized water, the seeds were rolled up in sterilized, moist germination paper and kept in an incubator at 25° C for 24 h. Two healthy germinating seeds were carefully transplanted to each cup. Whenever required, sterilized water was added to maintain moisture at about 40% water-holding capacity.

Table 1 Physico-chemical properties of the soils investigated

Soil series		pH	Organic C (%)	CEC c mol (p^+)/kg	Available nutrients (kg/ha)		Texture (%)		
					P	K	Sand	Silt	Clay
I	Phoolbagh clay loam	7.0	1.2	25.5	13.5	250	23.5	46.8	29.7
II	Beni silty clay loam	6.9	1.1	20.5	14.0	280	8.8	61.4	29.8
III	Haldi loam	7.5	1.2	18.0	12.2	275	33.2	49.5	17.3
IV	Nagla loam	6.8	1.0	18.9	12.0	200	39.1	38.1	22.8
V	Khamia sandy loam	6.7	1.0	11.5	12.0	182	57.7	28.3	14.0
VI	Patharchatta sandy loam	7.1	1.1	10.7	15.6	290	53.2	35.5	11.3

At 30 days, the plants were removed by inverting each cup. The roots were washed under the running tap water to remove sand particles, and excess water on the root surface was absorbed with filter paper. The roots were cut into pieces of approximately 1 cm and VAM infection was determined by the method of Phillips and Hayman (1970). The population of VAM propagules in soil was determined using the MPN table given by Alexander (1982).

Statistics

The significance of the correlation was determined by applying the *t*-test method.

Table 2 Population of VAM propagules in the soils of different soil series

Soil series		No. of VAM propagules/g soil	Confidence limit (95%)	
			Upper	Lower
I	Phoolbagh clay loam	4.9	1.62	0.15
II	Beni silty clay loam	4.0	1.32	0.12
III	Haldi loam	7.9	2.61	0.24
IV	Nagla loam	7.9	2.61	0.24
V	Khamia sandy loam	3.3	1.15	0.11
VI	Patharchatta sandy loam	13.0	4.29	0.39

Results and discussion

Soil properties

The physico-chemical characteristics of soils used for the MPN counts are given in Table 1. The pH of the various soils ranged from slightly acidic (pH 6.8) to slightly alkaline (pH 7.5). These soils were high in organic carbon, phosphorus and potassium. The CEC varied from 10.7 to 25.5 c.mol (p+)/kg. Four classes of soil texture, clay loam, silty clay loam, loam and sandy loam, were noted. The physico-chemical properties of the different soils agree with the results reported by Deshpande et al. (1971).

Table 3 Correlation coefficients (r) for populations of VAM propagules and physico-chemical properties of the soils investigated

Soil property		Correlation coefficient (r)
1.	pH	0.449
2.	Organic carbon	0.100
3.	CEC	−0.423
4.	Phosphorus	0.586
5.	Potassium	0.463
6.	Sand	0.398
7.	Silt	−0.247
8.	Clay	−0.555

Populations of VAM propagules and correlations with soil properties

The population of VAM propagules in the six soil series ranged from 3.3 propagules/g in Khamia sandy loam to 13.0 propagules/g in Patharchatta sandy loam (Table 2). The results corroborate the results of other workers (Hayman and Stonold 1979; Powell 1980; Peter and Christensen 1982; Rao et al. 1990). None of the series mollisols was found to be as high in VAM as the 20 spores/g soil reported by Daniels and Skipper (1982). This may be due to be characteristically high fertility of the soils examined here (Deshpande et al. 1971); many workers (Hayman 1970; Kruckelmann 1975; Hiremath et al. 1990) have reported low VAM populations in highly fertile soils compared with soils of low fertility.

Of the soil properties investigated (pH, organic C, sand, available phosphorus, available potassium, CEC, silt and clay contents) a significant correlation ($r = 0.586$, $P < 0.05$) was found for phosphorus and for the clay content of the soil ($r = -0.555$, $P < 0.05$). An increase in the VAM population with increasing pH agrees with the results obtained by Vyas and Srivastava (1987), who observed 14.27 spores/g soil at pH 8.0. A significant positive correlation with available phosphorus agrees with the results of several workers (Hayman 1970; Kruckelmann 1975; Hiremath et al. 1990; Shukla and Vanjare 1990).

References

Alexander M (1982) Most probable number method for microbial population. In: Black CA (ed) Methods of soil analysis, part 2: Chemical and microbiological properties. American Society of Agronomy, Madison, Wis, pp 1467–1472

Daniels BA, Skipper HD (1982) Methods for the recovery and quantitative estimation of propagules from soil. In: Schenck NC (ed) Methods and principles of mycorrhizal research. American Phytopathology Society, St Paul, Minn, pp 29–35

Deshpande SB, Fehrenbacher JB, Beavers AH (1971) Mollisols of Tarai region of Uttar Pradesh, Northern India. I. Morphology and mineralogy. II. Genesis and classification. Geoderma 6:179–195

Hayman DS (1970) Endogone spore numbers in soil and vesicular-arbuscular mycorrhizae in wheat as influenced by season and soil treatment. Trans Br Mycol Soc 54:53–63

Hayman DS, Stonold GE (1979) Spore populations and infectivity of vesicular-arbuscular mycorrhizal fungi in New South Wales. Aust J Bot 27:227–233

Hiremath PC, Harini Kumar KM, Patil CV (1990) Density of vesicular-arbuscular mycorrhizal fungi in different crops grown under black soil. In: Jalali BL, Chand H (eds) Current trends in mycorrhizal research. Haryana Agricultural University, Hisar, India, pp 20–21

Kruckelmann HW (1975) Effects of fertilizers, soil, soil tillage and plant species on the frequency of *Endogone* chlamydospores and mycorrhizal infection in arable soils. In: Sanders PE, Mosse B, Tinker PB (eds) Endomycorrhizas. Academic Press, London, pp 511–525

Peter D, Christensen M (1982) Mycorrhizal fungi associated with *Bouteloua* and *Agrophyron* in Wyoming sage brush grasslands. Mycologia 74:877–885

Phillips JM, Hayman DS (1970) Improved techniques for clearing roots and staining parasitic and VAM fungi for rapid assessment of infection. Trans Br Mycol Soc 55:158–161

Porter WM (1979) The most probable number method for enumerating infective propagules of vesicular-arbuscular mycorrhizal fungi in soil. Aust J Soil Res 117:515–519

Powell CL (1980) Mycorrhizal infectivity of eroded soils. Soil Biol Biochem 12:247–250

Rao VP, Pawar SE, Singh SN (1990) Distribution and intensity of native VAM in the Maharashtra region. In: Jalali BL, Chand H (eds) Current trends in mycorrhizal research. Haryana Agricultural University, Hisar, India, pp 162–163

Shukla BN, Vanjare N (1990) Extraction of vesicular-arbuscular mycorrhizae spores and effect of fertilizers on their population in oilseeds cropped soils. In: Jalali BL, Chand H (eds) Current trends in mycorrhizal research. Haryaha Agricultural University, Hisar, India, pp 33–34

Singh HP (1983) Studies on the interactions among rock phosphate, *Rhizobium*, mycorrhiza and phosphate solubilizers. PhD thesis, G. B. Pant University, Pantnagar, India

Vyas A, Srivastava HP (1987) Studies on vesicular-arbuscular mycorrhizae of mothbean. In: Varma AK, Oka AK, Mukerji KG, Tilak KVBR, Raj J (eds) Mycorrhiza round table. Jawaharlal Nehru University, New Delhi, pp 306–312