Distribution and interactions of surface roots of **Castilla elastica** (Moraceae) in lowland Costa Rica.*

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C O M P E N D I O

Para determinar la distribución de raíces menores de 1 mm de diámetro de Castilla elastica *se tomaron muestras de 20 x 20 cm a una profundidad de 10 cm en dos transecciones que partían del tronco. Las raíces estuvieron presentes hasta distancias de 20 a 35 m en las dos transecciones respectivamente. Las raíces de diámetro pequeño están concentradas (hasta 450 ml/m²) debajo de la copa, pero tienen apreciables concentraciones (hasta 276 ml m²) a distancias más grandes que el radio de la copa. Se discuten las implicaciones para el ciclo de nutrimentos y las relaciones competitivas. Se presentan hipótesis para estudiar las relaciones radicales en comunidades.* — El autor.

Introduction

THE present knowledge of root-distribution in the soil is superficial due to the difficulties involved in their study. Before significant progress can be made in the field of root ecology, basic questions concerning the distribution of roots will have to be answered. The lateral extent and depth profiles of the roots of individual trees will have to be determined, and the variability in these patterns must be assessed. Building on such information the mutual competitive effects of root systems on each other's location and form can be investigated in order to further clarify the structure of natural and agricultural plant communities. Such investigations will have to take account of the absorptive characteristics of different sizes and ages of roots as well as their mycorrhizal associations. This paper reports attemps to answer two of these initial questions using *Castilla elastica* which in common in secondary growth in wet tropical forests in Central America. *Castilla* is a tree of medium stature whose sap is used as a source of rubber. I wished to determine 1) distribution of surface roots of an isolated individual and 2) the relations of *Castilla* roots with others in the sample.

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Methods

The semi-isolated individual was located in a cacao plantation at Finca La Selva near Puerto Viejo, Heredia, Costa Rica. The subject tree had a diameter above buttresses (DAB) of 0.93 m and was 15.2 m distant from a smaller *Castilla* measuring 0.65 m DAB. The subject tree had a crown radius of 7-8 m. This site was chosen because, as a result of cultivation, there were no *Castilla* seedlings or saplings near the adult and the vegetational background was uniform. Roots of *Castilla* are bright yellow and contain latex, and can be distinguished from other roots in the samples using these characters. Roots were sampled on two transect lines from the base of the tree (Fig. 1). At 4, 7, 10, 13, 16, 20, 25, 30, and 35 m from the trunk of the tree, 20 x 20 cm cores were cut to a depth of 10 cm. If roots were absent at any point along a transect, a second, and if necessary a third, sample was examined 1 m east of the previous point. If no roots were found at two consecutive stations on a transect, sampling was terminated. The samples were taken in plastic bags to the Rio Puerto Viejo where the soil was washed from the roots in a hardware cloth sieve. Roots were separated into two classes at 1 mm diameter and the volume of roots in each class determined by displacement.

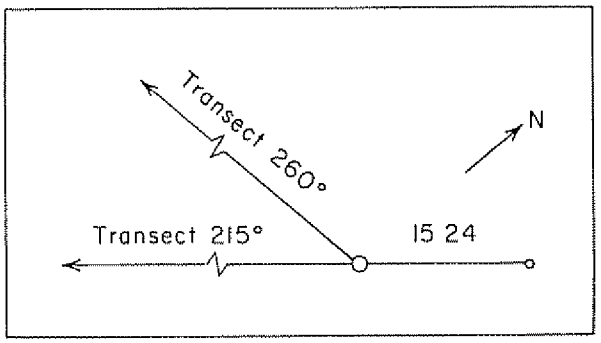

Fig. 1 —*Diagram of the study site showing the subject tree (1), the only neighboring conspecific individual (2), which is 15.24 m distant, and the two sample transects at 215° and 260°*

Results and discussion

Surface roots of *Castilla* were present to a distance of 20 m on transect 260° and to 35 m on transect 215°. The crown had a radius of 8 and 7 m on these transects respectively. Thus the roots on transect 215° had a radial extent 5 times greater than the crown (Fig. 2).

Root data in general are very meager and the volume estimates presented here are obviously crude due to the circumstances under which they were made. However, presentation of some questions and speculations may serve to encourage further research into root relations of plants.

Roots and crown structure

Correlations of root extent with root depth, stem diameter, degree of buttressing, height, age, and crown extent might provide information applicable to the study not only of individual plant strategies but also to the structure and functioning of communities. The placement of roots in relation to the crown may have implications for nutrient cycling. A concentration of a tree's own roots beneath its crown may allow a recapture of some portion of nutrients leached from its leaves and branches. Such a situation has been proposed to occur in *Quercus coccinea*, *Q. alba* and *Pinus rigida* in a temperate North American forest (10). It is likely however that the correlation of root and canopy structure is imposed by both exploitation competition and by the filling of soil space in saturated communities where resources are maximally utilized. Additionally, the effectiveness of root-canopy correlations in nutrient relations may be limited by preemption of leachates by the understory vegetation. Furthermore, the high frequency of rain (ca. 4 m/yr at La Selva) or low concentration of the leachate may decrease the value of root canopy correlation. A highly active and extensive surface mycorrhizal association in the usually very moist soil may negate the value of the proposed correlation. Estimation of the volume of roots less than 1 mm in diameter in concentric rings indicates that on both transects *Castilla* roots have their highest concentration beneath the crown, but that high concentrations are maintained outside the crown radius as well (Fig. 2). If this tree is a remnant from a more saturated community, then the great radial extent of its roots may be the result of competitive release. The reasons for this possibility are explored below.

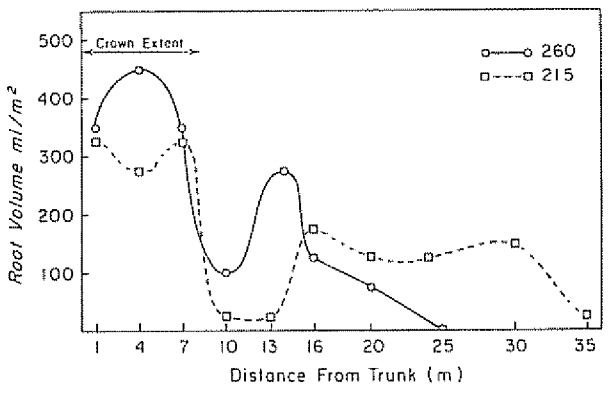

Fig. 2 —*Volume of* Castilla elastica *in ml m² less than 1 mm in diameter along the replicate transect lines. Crown radius is indicated by the arrow in the upper left-hand corner. Note the similarity of distribution on the two independent transects. Only small roots are shown due to their presumed activity in absorption.*

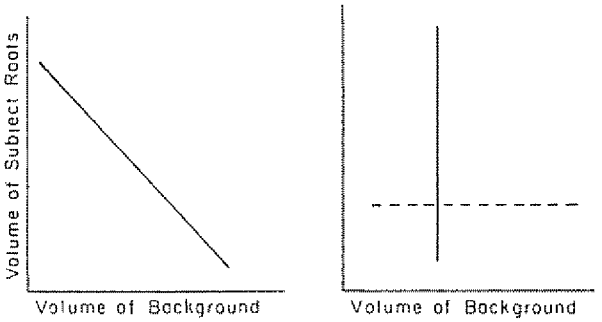

Fig. 3 —*Hypothesized relationships between volume of roots of a species and the volume of all others in the background. A. The relationship in a saturated community in which all roots are competitively equivalent. The negative correlation suggests competitive interaction. B. Two possible trends in an unsaturated environment or root niche differentiated community. The basic contrast between conditions A and B is between negative correlation and no correlation. Positive correlation between a species and the background could occur in a community that is coarse grained with respect to roots, that is, where various patches of soil are saturated at different total root volumes.*

Root distribution and competition

Assuming a saturated root environment and the competitive equivalence of all roots in a sample, an inverse relationship should exist between any one species and all other roots in a sample (Fig. 3a). An alternative plot showing no correlation of subject and background roots (Fig. 3b) would indicate either 1) a differentiation in function or microlocation of the different

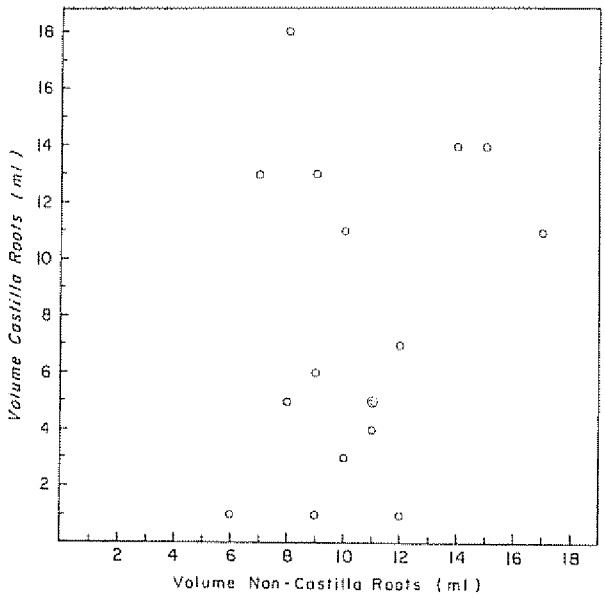

Fig. 1.—*Relationship of roots less than 1 mm in diameter in samples. Volumes of* Castilla elastica *and the background are not strongly correlated which may suggest an unsaturated soil environment*

roots, or 2) an unsaturated soil environment. The volume of *Castilla* roots appears to be independent of the background (Fig. 4). Because the study site is a plantation, an unsaturated soil environment might be expected, but niche differentiation, which does occur in non-equilibrium communities (6), cannot be ruled out.

Comparing root volumes of identifiable species in a sample with the amount of all others would be a valuable approach to determining the niche and competitive relationships of various natural and agricultural communities. The absorption of materials by roots within restricted radii enhances the probability that spatial and competitive overlap are directly related, an assumption that is often violated. Investigations could employ a transect between identifiable species pairs and transects from isolated individuals or in centrifugal directions from members of a pair, or extensive survey of the soil beneath a community. Trends in root space saturation along gradients of environmental severity, both spatial and successional, would be useful. It appears that root structure develops very early on in succession (2).

Tropical vs Temperate Plants and Communities

The great differences in above-ground structure of tropical and temperate forests (4, 8) make the examination of the structure of below-ground components of these systems a particularly pressing problem. Here, though, temperate research will have to be initiated simultaneously as very little is known of tree root distributions and interactions anywhere (but see 1, 3). Herbaceous communities are somewhat better known (9), but understanding forest patterns, particularly with respect to community organization, is mandatory.

Comparison of the structures of plants in vastly different climates which most likely present different disturbance regimes and large-scale successional dynamics (7) may provide some insight into the mechanisms by which these different climates are eventually expressed in temporal and structural characteristics of communities.

Conclusions

The core method of root sampling seems to be a viable one, particularly in high rainfall systems where most roots are concentrated in the extreme upper soil. Sampling to a depth of 10 or 20 cm in tropical systems will include very high proportions of the roots present (5). Using cores rather than tracing individual roots as they extend outward from the trunk can provide more information per unit effort. The tracing method will usually not include the small diameter roots, especially at the extremes of the root systems, due to breakage. Of course, the core method can only be used where at least some species roots are identifiable. Sap, color, branching pattern, degree of contortion and texture are characters which may prove to be useful in distinguishing roots. Self-cutting metal cores will improve the accuracy of volumetric estimates.

Using the core method, it was discovered that the roots of *Castilla elastica* have a great radial extent. This observation has stimulated the formation of several questions, hypotheses and approaches which, it is hoped, will encourage further, more refined research into the root relationships of communities.

Acknowledgements

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Summary

In order to determine the distribution of *Castilla elastica* roots less than 1 mm in diameter, 20 x 20 cm cores were taken to a depth of 10 cm on two transects from the trunk. The roots were present to distances of 20 m and 35 m on the two transects respectively. The small diameter roots are concentrated (up to 450 ml m^2) beneath the crown but have appreciable concentrations (up to 276 ml m^2) at distances greater than crown radius. Implications for nutrient cycling and competitive relationships are discussed. Hypotheses and approaches for studying root relationships of communities are presented.

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