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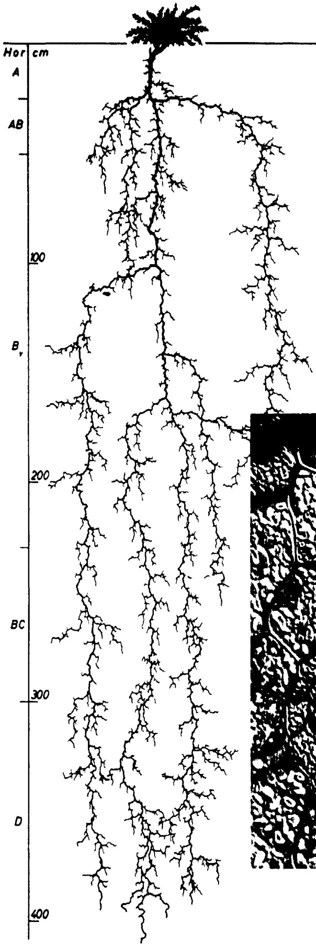

Root Ecology and its Practical Application 2

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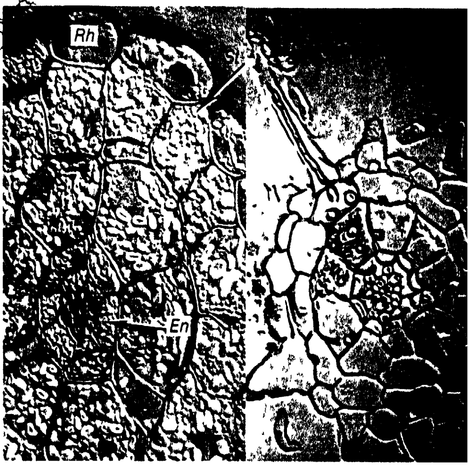

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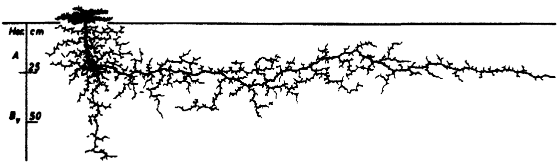

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(EDITORS)

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A Contribution to the Investigation of the Whole Plant (2)

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ROOTING BEHAVIOR OF INTERCROPPED PIGEONPEA (*CAJANUS CAJAN* (L.) MILLSPAUGH) AND SORGHUM (*SORGHUM BICOLOR* (L.) MOENCH)

Osamu Ito, Ryoichi Matsunaga, Satoshi Tobita, and Theertham P. Rao

SUMMARY: The rooting profiles of individual pigeonpea and sorghum plants were compared in monocropping and intercropping, under different planting densities, by use of a simple simulation approach. Pigeonpea did not show any characteristic advantages of root development over sorghum, probably due to the presence of a hard stony layer below 30 cm which consequently confined root proliferation within the surface layer of soil. The rooting depth was unaffected by the cropping pattern. The root proliferation near the plant base increased with plant age and was severely reduced by intercropping in case of pigeonpea. The intercropped sorghum had less roots initially but attained a similar density as monocropped sorghum at later stages. It is demonstrated that root development is considerably affected by the planting density.

1 INTRODUCTION: Intercropping is a common practice widely adopted by farmers in the semi-arid tropics to attain stability of both biological and economic productivities under highly variable environmental conditions. The combination of legumes and cereals is the most popular intercropping system. Although interaction between component plant species in intercropping should occur both above- and below-ground, most research has been focused on spatial arrangement of above-ground parts. However, the possible underground interactions such as competition for water and nutrient uptake, microbial activities, root exudates, allelopathy, and so on have not been extensively researched, especially in relation to the intercropping system (Snaydon and Harris, 1979).

The present studies were initiated to elucidate the below-ground interaction between component plant species of intercrops in relation to root distribution and major root activities such as respiration, nitrogen uptake and nitrogen fixation. In this paper particular emphasis will be put on the comparison of rooting profiles between two component crops in monocropping and intercropping.

2 MATERIALS AND METHODS: Medium-duration pigeonpea (ICP1-6) and hybrid sorghum (CSH5) were sown in shallow Alfisol on 12 June 1990. The planting densities were 60 x 15 cm for the monocrop of sorghum, 60 x 30 cm for the monocrop of pigeonpea and 60 x 10 cm for the sorghum : pigeonpea intercrop in 2:1 row arrangement. Nitrogen treatments were allotted to the main plots and cropping patterns to the sub-plots. Urea was broadcast at three levels (25, 50, 100 kg ha^{-1}) into each cropping pattern before sowing. Net plot area for each treatment was 5 x 2.4 m. Twenty kg ha^{-1} each of P and K were applied as basal nutrients, as single superphosphate and potassium chloride respectively. There were three replications. The root length was measured *in situ* in every 10 x 10 cm square between the two rows of crops down to 100 cm depth in trench wall excavated in field.

3 RESULTS: Roots observed in the soil wall in a trench represent the sum of roots intersecting the wall. In other words, the roots from plants standing behind the wall should have some contribution to root length density (RLD) measured on the wall. The degree of the contribution of each plant depends on the distance from the wall. Since a different planting distance within the row is commonly used between monocropping and intercropping, the comparison of the rooting profile is possible only when RLD for an individual plant in each case is calculated based on the obtained data. A set of data from a profile wall consists of 70 RLDs from a 10 x 10 cm cell in a 100 x 70 cm frame. Each cell is characterized according to the distance from the plant base which is designated as z. RLD (ρ) is expressed by a simple empirical equation, $\rho = \rho_o \, EXP(-kz)$ where ρ_o and k are coefficients characteristic of the plant. For simplification, the root development was assumed to be uniform in all directions from the plant base. The best fitted ρ_o and k were searched for against data obtained in field using a least square method by considering the plants behind the wall. In the case of intercropping where the density of plant population was highest, the simulation was closer to the observed data as more plants behind the wall were considered and reached a plateau when the seventh plant behind the wall including the plants at the wall were considered (Fig. 1). Based on this result, it was decided to account for up to 60 cm away from the wall, beyond which negligible contribution can be expected to the simulation as far as RLD is concerned. The simulation was found to be in satisfactory agreement with the observed data on RLD (Fig. 2).

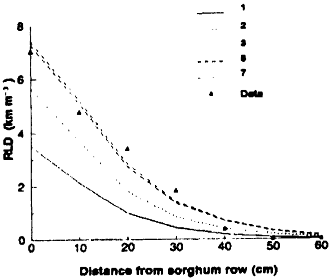

Fig.1. Effect of plant numbers behind trench wall on the simulation of root length density (RLD) of sorghum in intercropping at 48 days after sowing. Data obtained by in situ measurement are indicated with a symbol (▲).

The coefficients obtained from the simulation are given in Table 1 for pigeonpea and Table 2 for sorghum. The k determines the shape of exponential curve and is closely related with rooting depth. The ρ_o determines the intercept on the Y axis and represents the intensity of root proliferation near the plant base. There were no significant difference between

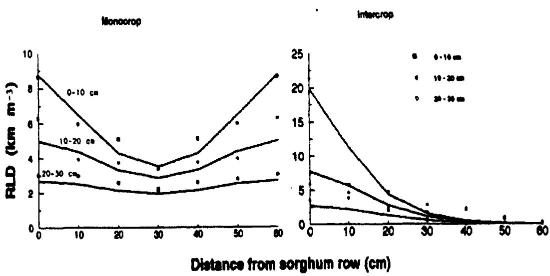

Fig.2. Root length density of monocrop and intercrop of sorghum obtained by field measurement (symbol) and simulation (line) at 123 days after sowing.

sorghum and pigeonpea for the coefficients, indicating that both crops showed similar rooting behavior under the field conditions used in the present experiment. Value of k was more or less constant regardless of crop species, cropping pattern and growth stage. The rooting depth was apparently very much restricted, even at the early growth stages. This could be due to the presence of a hard stony layer below 30 cm which interferes with root development. In pigeonpea, ρ_o was lower in intercropping than in monocropping and increased with plant age. In sorghum, which has faster initial growth rate than pigeonpea, ρ_o in monocropping was severely reduced at 84 DAS. After that, ρ_o in the monocropping remained unchanged, whereas ρ_o in the intercropping increased.

Table 1. Coefficients obtained by simulation for the estimation of root length density of pigeonpea in monocropping and intercropping.

	k		ρ_o	
DAS	Monocrop	Intercrop	Monocrop	Intercrop
84	0.083 (0.013)	0.094 (0.003)	11.8 (2.7)	9.4 (0.8)
123	0.079 (0.004)	0.077 (0.009)	16.1 (2.2)	9.1 (2.5)
169	0.086 (0.013)	0.070 (0.004)	23.5 (5.4)	11.5 (1.7)

Values for the three nitrogen treatments are combined.
Figures in parentheses are standard errors.

Table 2. Coefficients obtained by simulation for the estimation of root length density of sorghum in monocropping and intercropping.

	k		ρ_o	
	Monocrop	Intercrop	Monocrop	Intercrop
84	0.085 (0.009)	0.084 (0.007)	10.0 (2.9)	6.1 (1.0)
123	0.078 (0.006)	0.091 (0.004)	8.8 (2.0)	12.9 (4.1)

4 DISCUSSION: Pigeonpea is reported to develop a deeper root system than soybean and maize on Alfisol (Arihara et al. 1991). In the present studies, no significant difference was found between pigeonpea and sorghum in rooting depth, as evident by k. This could probably be due to the presence of a hardpan layer at around 30 cm depth. It was observed on the trench wall that only a few roots had penetrated down through the layer. Pigeonpea restricted downward development of tap root at this point and extended the primary root more into the horizontal direction. This is clearly shown in Fig. 3 where the vertical root profile is compared with the horizontal in intercropping. Sorghum had a similar profile in both directions, whereas pigeonpea showed more condensed distribution in the horizontal direction. This indicates that uniform root development in all directions which is assumed in the present simulation is applicable only for sorghum (Suga et al. 1988). Although an alternative approach considering the direction of root development should be employed in case of pigeonpea, the present simulation may be still worthwhile to compare root development at the different planting densities which is common between monocropping and intercropping.

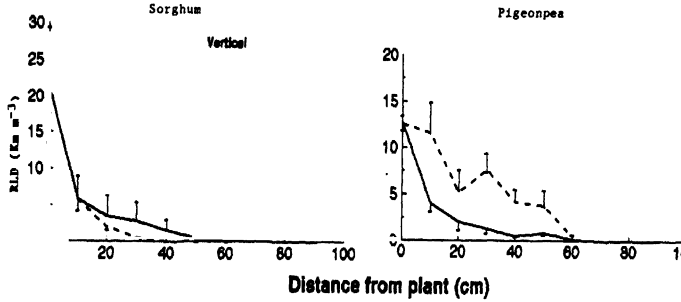

Fig.3. Vertical and horizontal profiles of root length density of sorghum and pigeonpea in intercropping at 123 days after sowing.

Intercropping did not alter the rooting depth of either crop, while it decreased root development within the soil profile as a whole. This may be closely associated with the reduction of shoot growth caused by shading. A greater reduction in ρ_o was observed in pigeonpea in intercropping where the planting density was three times more than in monocropping. The root proliferation of sorghum in intercropping was reduced initially, but increased to the level of intercropping by harvest, probably because of only 1.5 times difference in the planting density between monocropping and intercropping. The present approach has proved to be useful for the comparison of root systems at different planting densities.

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