ABSTRACT

A study dealing with the distribution of roots in the soil profile was made in representative and commercially grown fields of the Casa Grande Cooperative. Samples were made in both plant canes and ratoons from 4 to 19 months of age.

The results show that roots grow down to 180 cm depth, with approximately 85% of them within the first 60 cm. Root development is influenced by irrigation. High volumes cause a deeper root development, otherwise, light applications induce a superficial one.

Moreover, under the experimental conditions, it has been found that the age is not an additional factor in the distribution of roots, nor the cultivar or number of harvests.

INTRODUCTION

Sugarcane roots are responsible for the fixation and absorption of nutrients and water that the plant needs for its own growth. The physical and mechanical characteristics of soil which are inappropriate for its normal development, have negative effects on the growth and development of the plant. Some effects are indirect through their influence on the moisture, aeration and nutrients supply, whereas others, such as the mechanical resistance offered by a hard layer against penetration of roots, directly perform negative influences on the growth and distribution of roots. Compaction is a natural fact that can be accelerated as a consequence of the mechanized operations and with different results, depending mainly on the soil structural stability and its moisture degree. Additional ecologic factors, such as the high water tables, alter the normal development of roots influencing their depth and distribution.

Many researchers relate the soil physical characteristics to root development by means of the texture values or bulk density. Veihmeyer and Hendrickson suggest that roots do not penetrate in soils with bulk densities greater than 1.9 g/cm³, for clayey soils the critical values are still lower. For sugarcane Baver as cited by Gomez and Pinto, reports growth restrictions in the root system by presence of hard soil layers. Trouse and Humbert indicate that the growing rates of roots vary
with the bulk density, and that at bulk densities greater than 1.46 g/cm³, the penetration is heavily reduced, and in soils with values over 1.52 the penetration is null. The same authors did not find differences in root development for critical values of bulk density at different moisture levels.

Gomez, and Pinto in cane-growing soils found bulk density values from 1.7 to 1.8 g/cm³ in poor growing areas. Botta and Volfo on studying the morphology of the root system in the cultivars B-4362 and C-8757, under crop normal conditions in Cuba, determined that more than 70% of roots are found within the first 30 cm depth, about the 20% within the following 30 cm depth, and the remaining percentage below the 60 cm depth, reaching depths down to 180 cm. Neumann mentions that the roots are found in a great proportion in the first 60 cm in appropriate conditions of soil and moisture where they penetrate very deeply, reaching 120 cm or more. For scheduling irrigation for sugarcane in Mexico, Gonzalez and Ortiz indicated that sugarcane develops about the 90% of its roots in the first 60 cm depth, with the 60% in the first 30 cm. Baran et al report that root development at the lower soil horizons was greater when the crop was less frequently irrigated.

For soils with water tables below 80 cm depth, bulk densities of 1.38 to 1.56 g/cm³, and salinity levels of less than 7 mmhos/cm, Barreto found that approximately the 60% of roots develop in the first 30 cm, with the 80% in the first 60 cm, and almost 95% down to 90 cm depth.

Epplink and Bazan on studying the effects of static water tables on root development of cultivar H32-8560, found that the water table position determines its roots distribution which show a dynamic variation through the profile adapting themselves to the conditions usually present in the soil. The same authors annotate that when the plant is in unfavorable moisture conditions, the root system develops in such a way that great part of the roots are found below the 60 cm. In normal conditions, approximately 70% of roots are found in the first 70 cm, about the 90% down to 90 cm, and almost 100% within the 120 cm depth.

MATERIALS AND METHODS

The study was carried out in eleven representative fields of the Cooperativa Agraria de Produccion (CAP) Casa Grande, nine of which were cultivated with H32-8560 and two with H57-5174. Four pits per field were dug for samplings, the same that were taken at layers of 30 cm down to the depth of 180 cm, using the dry sifting method for the evaluation of samples, (Epplink and Bazan). The selected fields have loam to silty loam texture (40 < \( K_a \) * 65), low salinity (0.76 < \( EC_e \) ** < 1.87), and average bulk density in the first 90 cm of 1.32 to 1.46 g/cm³. At sampling time, two of the fields were with plant cane, four were with first ratoon, three with second, one with third and one with fourth. Their ages are as follows: one field, five months; five, between six and twelve months; and the remaining five, of more than twelve months.

\* \( K_a \), moisture percentage of saturated paste.

\*\* \( EC_e \), electrical conductivity of saturation extract in mmhos/cm.
The characteristics of the irrigation applied to each field were recorded, taking down the applied volume per irrigation, number and interval of irrigations.

The probability density curve of the percentage of roots per layers and a graphic correlation between the mean volume applied per irrigation and the average percentage of roots per layers were established. Correlations (multiple) between the % roots per layers, with the age, number of crop, cultivar, and the respective variance analyses were also made with the purpose of determining the influence of these factors on the development and distribution of roots.

RESULTS AND DISCUSSION

The results are summarized in Table 1, where the roots distribution per field and per layer of 30 cm each as well as the physical characteristics of saturation percentage ($K_a$), bulk density ($DA$), soil salinity ($CE$), cultivar, number of crop, age at date of sampling, and irrigation regime applied to each field are shown.

![Figure 1. Probability density of sugarcane roots percentage (%) per 30 cm of soil depth.](image)

The percentage of roots distribution per layer is represented in Fig. 1 by means of the probability density curve; where it can be observed that around 60% of roots is distributed within the first 30 cm, about 85% within the first 60 cm, and approximately the 94% within the first 90 cm depth. The negative skewness in the 00-30 cm curve, indicates that values less than the 40% are somewhat frequent. Likewise, the skewness of the 30-60 cm curve also indicates the usual lesser frequency that percentages greater than the 40% have within this layer. The values of the
coefficient of variability that are shown in Table 1 also indicate that root distribution below the 60 cm is more variable than in the underlying layers; being less variable in the first one. This type of distribution is the same with that described by Neumann\textsuperscript{5}, Barreto\textsuperscript{8}, Eppink and Bazan\textsuperscript{9}, Gonzales and Ortiz\textsuperscript{6}, but somewhat different to that found by Botta and Volf\textsuperscript{4}, mainly at the root distribution within the layers of 00-30 cm (70\%) and 30-60 (20\%) probably because the root distribution pattern is determined, in this cases, by different ecology and grown cultivars.

**FIGURE 2.** Roots distribution as a function of the average volume applied by irrigation.

Fig. 2 reveals that the form of root distribution with depth is related to the irrigation regime; thus abundant applications of water by irrigations with extended intervals between them, caused greater root development at the lower layers. Otherwise, light applications by frequent irrigation generated a superficial development. Baran et al\textsuperscript{7}, Neumann\textsuperscript{5}, Eppink and Bazan\textsuperscript{9} also indicated that root development is related to both the irrigation regime and the moisture in the profile.
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<tr>
<th>Field</th>
<th>Cultivar</th>
<th>Harvest</th>
<th>Age at sampling days</th>
<th>No. of Irrigations at sampling intervals</th>
<th>Average interval days</th>
<th>Mean Volume per irrigation m³/ha</th>
<th>Total Volume at date of sampling m³</th>
<th>% roots per layers of 30 cm</th>
<th>K_A</th>
<th>C_e</th>
<th>²</th>
<th>D_A</th>
<th>³</th>
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</table>

**SUMMARY**

- Average (x): 9
- Standard deviation (S): 4
- Coefficient of variability (CV): 0.36
- Modal (MO): 63.1

*Moisture percentage of saturated paste.*

*Electrical conductivity of soil saturation extract in mhos/cm.*

*Bulk density in g/cm³.*

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**TABLE 1. Summary of soil characteristics per field, irrigation regime, cultivar, age, harvest, and distribution of roots.**
Bulk density values of sampled fields are below those considered by the international literature as critical for normal root development (Veihmeyer and Hendrickson, Trouse and Humbert, Gomez and Pinto, and others). The textural characteristics and salinity values were not also limiting for root development and only in limited cases some profiles showed a coarse texture and stones within the lower layers.

Under the experimental conditions, the established correlation between the percentage of root per layer and age, does not show levels of casual association \( r = 0.36 \); either with the cultivars or with the crops.

**CONCLUSIONS**

In the Peruvian coastal north, the sugarcane crop develops its roots down to the depth of 1.80 m, with 85% being frequently found in the first 60 cm of profile, from which the 60% is generally found in the first 30 cm.

For the ecologic conditions and irrigation regime used in the sugarcane crop in the north coast of Peru the root development is influenced by irrigation. Abundant applications of water with extended irrigation intervals induce a deeper root development; whereas, light and frequent irrigation causes a superficial one.

The distribution of roots within the first layers (00-30 and 30-60) shows less variations than those in the deeper layers. The characteristics of the probability density curve in the first two layers indicate that generally more than two-thirds \((2/3)\) of the roots are distributed in the first 60 cm depth.

Due to the discreet value of the coefficient of correlation between the distribution by layers and age at sampling, it is inferred that this has not been an additional factor in the form of distribution of roots at the profile, and/or that at the age of sampling (age > 4 months) the roots profile apparently has a complete development. Likewise, bulk density values and salinity levels have not been restrictive for root development. The number of harvests and the cultivar did not influence root development.

**REFERENCES**


DESARROLLO RADICULAR DE CULTIVARES DE CANA DE AZUCAR H32-8560 y H57-5174, BAJO CONDICIONES NORMALES DE CULTIVO Y Riego EN EL VALLE CHICAMA

J. E. Paz-Vergara, A. Vasquez, W. Iglesias and J. C. Sevilla

RESUMEN

Fue hecho un estudio para apreciar la distribución de las raíces en el perfil del suelo de campos comerciales de caña de azúcar en la Cooperativa Casa Grande. Las muestras fueron tomadas tanto en caña planta como seca de 4 a 19 meses de edad.

Los resultados demuestran que las raíces crecen hasta 180 cm. en profundidad, estando aproximadamente el 85% de ellas en los primeros 60 cm.

El desarrollo radicular está influido por la irrigación. Altos volúmenes de agua causan un desarrollo radicular profundo, mientras que por otro lado, aplicaciones ligeras inducen a raíces superficiales.

Así mismo, bajo condiciones experimentales se ha encontrado que la edad no es un factor adicional causante de la distribución radicular, ya sea en el cultivar o en el número de cosechas.