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Nitrogen fertilization and harvesting age effect on sugarcane thresholds for soil salinity

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Abstract The aim of this study was to determine if harvesting age or N fertilization affects salinity threshold. The study was undertaken in the Peruvian northern coast in a moderately saline soil (1.98-8.66 dS/m). Six rates of N (0, 180, 250, 320, 390 and 460 kg N /ha) per age, with four replications were studied at five harvest ages (12.3, 15.5, 20.0, 23.3 and 26.5 months). Cultivar H32-8560 (plant cane) was used. Correlations were made between yield and relative yield results, with mean salinity of top 60 cm of soil at planting, with N rates, and with cane age. It was found that sugarcane is moderately sensitive to salty soils, more close to sensitive that to moderately tolerant. Soil salinity threshold is 1.6 dS/m. Yield decline is about 10% per dS/m. N fertilization does not affect salt tolerance of sugarcane. Harvesting age does not affect salt tolerance. When salinity is lower than 2 dS/m, yield increases with age at harvest, when over 4 dS/m yields do not increase between 23.3 and 26.6 months age at harvest, and when over 8 dS/m yields do not increase with age at harvest.

Key words Sugarcane, saline soils, nitrogen

INTRODUCTION

Sugarcane is one of the most important crops in the irrigated valleys of the Peruvian north coast. One area in particular consists of saline soils. Although it is well-known that soil salinity affects sugarcane yield (Wahid 2004; Ashraf *et al*. 2012), studies in Peru (Valdivia 1980; Pinna 1974; Valdivia and Pinna 1974; Valdivia and Pinna 1980) have not identified specific salinity threshold for sugarcane cultivar H32-8560, although it is widely planted in these areas. In addition, there is no information about the yield effect per unit (dS/m) of soil salinity. Nour *et al.* (1989), Wiegand *et al.* (1996), Bernstein *et al.* (1974) and Kingston and Anink (2005) reported that different cultivars, and plant and ratoon crops had different yield responses to levels of soil salinity.

Maas and Hoffman (1977) proposed a saline tolerance classification framework for most crops, and indicated that sugarcane is moderately sensitive to soil salinity. Kingston and Anink (2005) suggested that sugarcane cultivars be classified in the ranges moderately tolerant to sensitive, or moderately sensitive to sensitive. Their work indicated that sensitive/tolerance to salinity is cultivar-specific and that it is necessary to know the rating for each cultivar. They established that the salinity threshold was 1.7 dS/m for the sugarcane cultivars they studied and that there was a yield reduction of 5.9% for each unit increase in salinity (dS/m).

There appears to be little information in literature about the effect of harvest age on yields of sugarcane grown in saline soils. Bernstein *et al.* (1974) and Maas and Hoffman (1977) working with other crops, found that additional fertilizer, or nitrogen (N) deficiency did not changes salt tolerance, and that when salt limited yields, responses to fertiliser decreased. Valdivia and Pinna (1980) reported similar results: there was no yield increases when N was applied to sugarcane grown in saline soils, in contrast to the yield response to N applied to non-saline soils. They did not mention N effects on salt tolerance.

The aim of our study was to determine whether harvest age or N fertilizer affects the salinity threshold in sugarcane, and to determine the yield reduction per unit increase in soil salinity for cultivar H32-8560.

MATERIALS AND METHODS

We used a randomised complete-block design in a trial in the arid region of the Peruvian north coast. It consisted of six rates of N (0, 180, 250, 320, 390, 460 kg N/ha) applied to sugarcane cultivar H32-8560 planted in an alluvial soil (Entisols),

described as calcareous, slightly to moderately alkaline (pH 7.5-8.2) and moderately saline (1.98-8.66 dS/m), with a predominately loamy clay texture (Valdivia and Pinna 1980).The cane was harvested at five ages (12.3, 15.5, 20.0, 23.3, 26.5 months). Sugarcane yield and relative yield were plotted against mean soil salinity (0-600 mm) determined prior to planting for the different N rates and harvest ages.

RESULTS AND DISCUSSION

There were no significant relationships between salinity and relative yield for 0 and 180 kg N/ha, but relationships were highly significant for the higher doses (Fig. 1). These higher doses are in the salt moderately sensitive, more close to sensitive that to moderately tolerant. All curves are in a single salt tolerance category. Our results confirm that sugarcane tolerance to soil salinity is a cultivar characteristic (Kingston and Anink 2005), and that H32-8560 is moderately sensitive to salty soils.

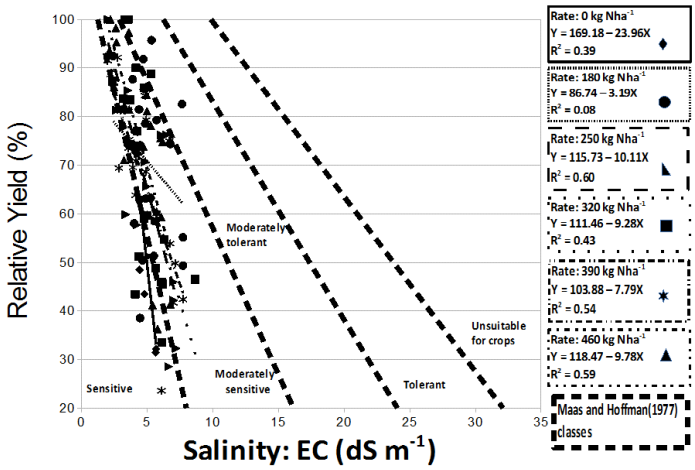


Fig. 1. Linear relationships between salinity levels and relative yields for different N rates.

Resolving the linear equations, soil salinity thresholds were 1.6; 1.2; 0.5; 1.9 dS/m, for 250, 320, 390, 460 kg N/ha, respectively. That means that with exception of 390 kg N/ha, average thresholds are around 1.6 dS/m. Variation at 390 kg N/ha confirms the difficulties in determining salinity effects under field conditions.

The coefficients of the linear equations show that yield decline was 10.11; 9.28; 7.79; 9.78 % per dS/m for 250, 320, 390, 460 kg N/ha, respectively, or all about 10%. This confirms that N fertilization does not affect salt tolerance of sugarcane.

There were no significant correlations between salinity and relative yield for 12.3 months age at harvest, but it was highly significant for the other ages (Fig. 2). These other ages are salt moderately sensitive, more close to sensitive that to moderately tolerant.

Soil salinity thresholds were 1.5; 0.5; 2.0; 1.2 dS/m, for 15.5, 20.0, 23.3, 26.5 months harvesting age, meaning that with the exception of 20 months, average thresholds are about 1.6 dS/m, agreeing with the N relationships. The poor definition of a threshold for 20 months again confirms the difficulties in determining salinity effects under field conditions.

Yield decline was 7.36; 8.61; 10.58; 10.8 % per dS/m for 15.5, 20.0, 23.3, 26.5 months harvesting age, all around 10%, which agrees with the one found for N effect. This confirms that harvest age does not affect salt tolerance of sugarcane.

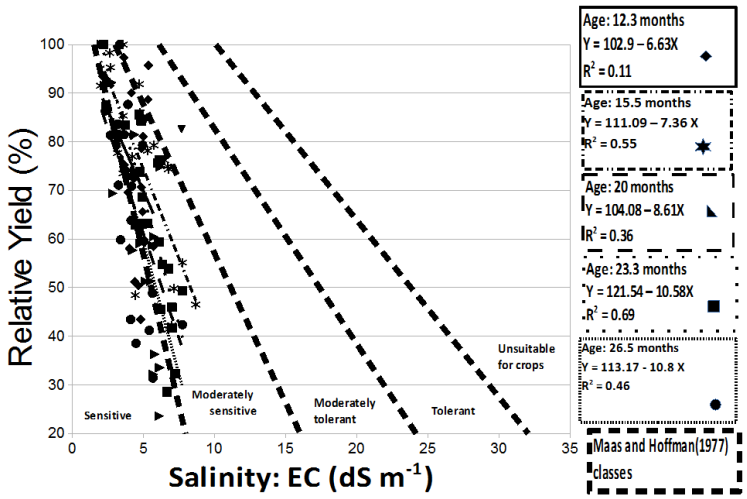


Fig. 2. Linear relationships between salinity levels and relative yields for different ages at harvest.

If results are considered as absolute yields, and not relative yields, there were no significant relationships between salinity and yield for 12.3 months harvesting age, but there were highly significant relationships for other harvesting ages (Fig. 3). When salinity is lower than 2 dS/m, yields increased with harvesting age, the normal situation. When salinity is over 4 dS/m, yield do not increase between 23.3 and 26.6 months, if over 4.5 dS/m yields do not increase between 15.5 and 20.0 months, and if over 8 dS/m, yields do not increase with harvesting age. This suggests that in slightly saline soils harvesting age must be early.

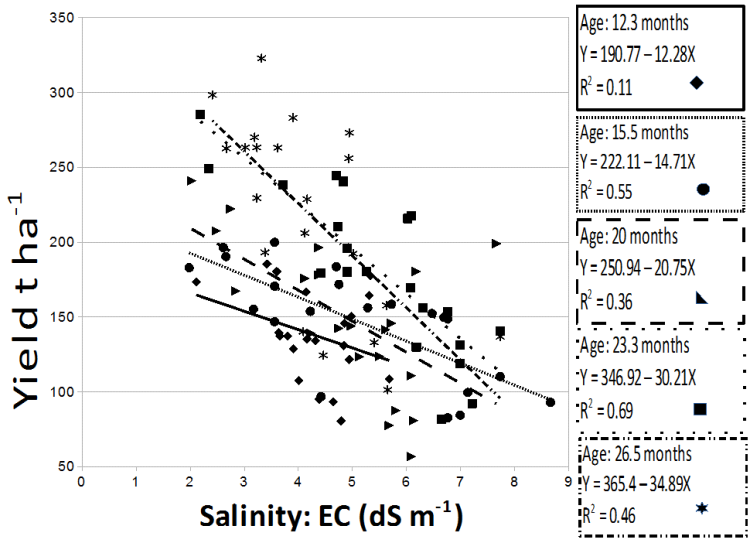


Fig. 3. Linear relationships between salinity levels and actual yields for different ages at harvest.

CONCLUSIONS

Cultivar H32-8560 is moderately sensitive to salty soils, more close to sensitive that to moderately tolerant. Sugarcane tolerance to soil salinity is a cultivar characteristic. Soil salinity threshold for H32-8560 sugarcane cultivar is about 1.6°dS/m. Yield decline is around 10% per dS/m.

N fertilization and harvesting age do not affect salt tolerance of sugarcane.

When salinity is lower than 2 dS/m, yields increase with harvesting age, over 4 dS/m yield, do not increase between 23.3 and 26.6 months; and over 8 dS/m yields do not increase with harvesting age.

We found some contradictory results that demonstrate the difficulties in determining salinity effects under field conditions.

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Effet de la fertilisation azotée et de l'âge à la récolte sur les seuils de salinité du sol pour la canne a sucre

Résumé. L'objectif de cette étude est de déterminer si l'âge à la récolte ou la fertilisation azotée a une influence sur le seuil de salinité du sol. L'étude a été réalisée au nord de la côte du Pérou dans un sol modérément salin (1.98-8.66 dS/m). Le dispositif expérimental était constitué de six taux de N (0, 180, 250, 320, 390 et 460 kg N/ha) par rapport à l'âge, cinq dates de coupe (12,3, 15,5, 20,0, 23,3 et 26,5 mois) avec quatre répétitions. La variété utilisée (en canne vierge) était la H32-8560. Des corrélations ont été établies entre le rendement et la salinité moyenne de la couche supérieure de 60 cm du sol, le taux de N et l'âge de la canne à la récolte. Il a était constaté que la canne à sucre est modérément sensible à des sols salins et plutôt sensible que modérément tolérante. Le seuil de salinité du sol était de 1,6 dS/m avec une baisse de rendement d'environ 10% par dS/m. La tolérance à la salinité de la canne à sucre n'est pas affectée par la fertilisation en N ou par l'âge à la récolte. Lorsque la salinité est inférieure à 2 dS/m, le rendement augmente avec l'âge à la récolte, alors qu'au dessus de 4 dS/m, il n'y a pas d'augmentation de rendement quand l'âge à la récolte passe de 23,3 à 26,5 mois. Au dessus de 8 dS/m l'âge à récolte n'a aucune incidence sur le rendement.

Mots-clés: Canne à sucre, sols salins, azote

Efecto de la fertilización nitrogenada y de la edad de cosecha en el umbral de afectación por sales a la caña de azúcar

Resumen. El objetivo de este estudio fue determinar si la edad de la caña o la fertilización nitrogenada afectan el umbral de afectación por sales en el suelo, a dicho cultivo. El presente trabajo se efectuó en la costa norte peruana. En un suelo moderadamente salino (1.98-8.66 dS/m), seis dosis de N (0, 180, 250, 320, 390, y 460 kg N/ha) por edad, con cuatro repeticiones, fueron estudiadas, a cinco edades

de cosecha (12.3, 15.5, 20.0, 23.3, y 26.5 meses). Se trabajó con el cultivar de caña H32-8560 (caña planta). Se efectuaron correlaciones entre los rendimientos de caña, y los rendimientos relativos, con la salinidad promedio de los primeros 60 cm del suelo, a la siembra; con las dosis de N, y con la edad de cosecha de la caña. Se encontró que la caña de azúcar es moderadamente sensible a la salinidad, más cercana a sensible que a moderadamente tolerante. El umbral de salinidad del suelo es 1.6 dS/m. La disminución del rendimiento es alrededor del 10% por dS/m. La fertilización nitrogenada no afecta la tolerancia a las sales de la caña de azúcar. La edad de cosecha no afecta la tolerancia a las sales de la caña. Cuando la salinidad es menor que 2 dS/m, los rendimientos aumentan con la edad de cosecha, sobre 4 dS/m los rendimientos no aumentan entre 23.3 y 26.6 meses de edad de cosecha; y sobre los 8 dS/m los rendimientos no aumentan con la edad.

Palabras clave: Caña de azúcar, suelos salinos, nitrógeno