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Effects of Flooding Stress at Different Stages on Growth and Aerenchyma Formation in Adventitious Roots of Sugarcane under Greenhouse Conditions.

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ABSTRACT

The greenhouse experiment was conducted to investigate the effects of flooding stress at different growth stages on shoot growth and adventitious roots development, as well as aerenchyma formation in roots of sugarcane. Flooding stress at 2,3 and 4 months of age for 30 days in comparison with non-flooding (control) were assigned in completely randomized design with three replications. Results revealed that stem fresh weight (economic yield) experienced to flooding at different growth stages did not showed significant difference as compared to non-flooding control. During flooding, adventitious roots appeared from the submerged nodes which well-developed aerenchyma that act as adapted mechanism to this condition. This indicates that sugarcane could sustain high yields when their grown in the upper paddy field under climate change in recent year.

Keywords: sugarcane, flooding stress, adventitious roots, aerenchyma formation

INTRODUCTION

In northeastern Thailand, most of growing riceland can be divided to upper and lower paddy fields under typical mini-watershed undulating land form. In general, short growing period rice cultivars cultivated in the upper paddy fields. Recently, due to climate change caused rainfall stop early in the rainy season. Rice crop, normally, produced low yields. Shift of land use pattern by growing sugarcane economic crop replacing to rice is recommended in the upper paddy fields. However, sugarcane may experienced to flooding stress during high intensity of rainfall months. Therefore, the objectives of this research was to investigate the effects of flooding stress on shoot growth, and adventitious roots growth, as well as aerenchyma formation that act as adaptation mechanism to flooding stress of sugarcane.

METHODOLOGY

The experiment simulated a planting schedule that was similarly to the Thailand pattern of planting date in the early rainy season. Sugarcane will be experienced to flooding stress during the high intensity of rainfall months (July-September). The completely randomized design with three replications was laid out in the present study. The treatments consist of the sugarcane experienced to flooding at 2, 3 and 4 months of age for 30 days, comparison with non-flooding control (Figure 1). Water level maintained at 10 cm above soil surface during the flooding treated period. Adaptation mechanism to flooding stress by developing adventitious roots and aerenchyma formation were determined at the end of flooding treated period. Shoot growth was measured at the end of flooding treated period and at harvest (8 months).

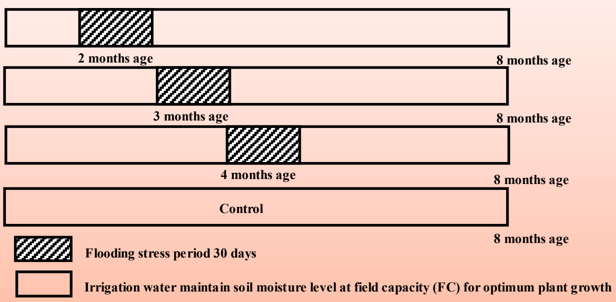

Figure 1 Growth stages at which flooding treated of the experiment.

RESULTS AND DISCUSSION

Sugarcane experienced to flooding at different growth stages were significantly different in leaves area ($p \leq 0.01$), leaves dry weight ($p \leq 0.05$) and adventitious roots dry weight ($p \leq 0.01$) of sugarcane, but there were not significant difference ($p \leq 0.05$) in plant height, tiller number, stem fresh weight and stem dry weight of sugarcane (Table1). The maximum leaves area and leaves dry weight were observed in the non-flooding (control) treatment. In the present study, adventitious roots dry weight were significantly different ($p \leq 0.01$) between flooding of age (growth stages) treatments (Table 1). The highest adventitious roots dry weight was observed when the plants were flooded at 4 months age (Figure 2).

Table 1 Growth performance at harvest (8 months) of sugarcane affected by flooding stress at different stages of growth under greenhouse conditions.

Parameters	Age at which flooding treated			Non-flooding (control)	F-test
	2 months	3 months	4 months		
Plant height (cm)	290.3	279.0	300.3	258.3	NS
Tiller number (no.plant^{-1})	6.7	7.7	6.	10.0	NS
Leaves area (cm^2 plant^{-1})	11,269ab	10,303b	856b	11,756a	**
Leave dry weight (gm plant^{-1})	201.9ab	213.3a	172.8b	239.3a	*
Stem fresh weight (gm plant^{-1})	1556.4	1392.7	1360.0	1770.0	NS
Stem dry weight (gm plant^{-1})	885.8	837.1	718.1	946.0	NS
Adventitious root DW (gm plant^{-1})	3.43c	10.36b	15.83a	none	**

Remark: *, ** significant at the 0.05 and 0.01 probability level. NS, non-significant at the 0.05 probability level.
Different letters indicate statistical significance at the 0.05 probability level within the same row.
DW = dry weight.

Figure 2 Adventitious roots development at different growth stages of sugarcane treated by flooding.

In addition, adventitious roots had developed aerenchyma better adapted to these conditions than the original roots. Aerenchyma formation in the adventitious roots increased porosity in the cortex supply oxygen (Figure 3) (Drew,1997; Laan et al., 1991). The economic yield of sugarcane measured by stem fresh weight/ stem dry weight per plant did not result in a significant reduction as compared to non-flooding control in the present study. This indicates that sugarcane crop is fairly tolerance to flooding stress.

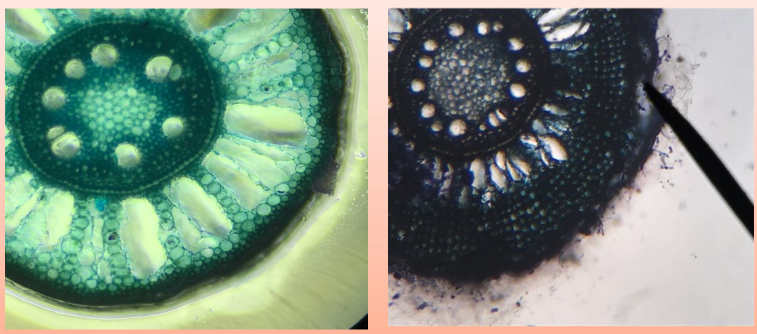

Figure 3 Aerenchyma formation increased porosity in the cortex of adventitious root during flood. Cross section was made at 1 cm above the tip (pictures (a), adventitious root; (b), original root).

SELECTED REFERENCE

Drew, M.C.1997. Oxygen deficiency and root metabolism: Injury and acclimation under hypoxia and anoxia. Annual Review of Plant Physiology and Plant molecular Biology, 48: 233-250., Laan, P., Clement, J.M. AM. and Blem, C. W. P. M. 1991. Growth and development of Rumex root as affected by hypoxic and anoxic conditions. Plant Soil, 136: 145-151.