SHORT COMMUNICATION

RAPID BULKING AND TESTING OF COLD TOLERANT VARIETIES IMPORTED FROM LOUISIANA

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Abstract

In sugarcane producing regions of the Midlands of KwaZulu-Natal province in South Africa, frost occurs frequently during winter in low-lying areas (frost pockets). Frosted sugarcane often has to be harvested when the stalks are immature and sucrose content and cane yield are low. Early harvesting is common practice in the Midlands to avoid the detrimental after-effects of frost damage, which include quality deterioration. Where frost pockets occur, there is great demand for frost tolerant sugarcane varieties to improve profitability. In Louisiana, USA, sugarcane is harvested young due to cold winter conditions. Two fast-maturing Louisiana varieties (LCP 85-384 and HOCP 96-540) and two South African Midlands varieties (N21 and N36) were evaluated for frost tolerance. All varieties were bulked-up using the NovaCane® tissue culture protocol. A field trial was established during October 2007 in a typical valley-bottom frost pocket at New Hanover in the Midlands North area. The Performance Index (PI_{ABS}), a sensitive indicator of photosynthetic electron transport efficiency, was derived from chlorophyll *a* fluorescence measurements performed on leaves of the varieties before and after frost events. Varieties N21 and HOCP 96-540 responded the most severely to frost, with PI_{ABS} values reduced by up to 50% compared to N36 and LCP 85-384. Subsequent analysis revealed that N36 and LCP 85-384 were capable of cold acclimation following the first frost event, allowing maintenance of photosynthesis for longer. This led to substantially higher stalk sucrose accumulation capacity that resulted in up to 30% higher sucrose yields (t/ha) in these two varieties than in N21.

Keywords: NovaCane®, tissue culture, sugarcane, varieties, frost, cold tolerance, chlorophyll *a* fluorescence

Introduction

Cultivating sugarcane in frost-prone areas often necessitates shorter growing cycles in order to escape detrimental after-effects of frost, such as cane deterioration (Eggleston *et al*., 2004). Frost is common in the Midlands region of Kwazulu-Natal province in South Africa, especially in so-called ‘frost pockets’. Annual harvesting of sugarcane in the Midlands is not profitable because the full yield potential of the crop is usually attained at 18-24 months of age. There is a need to identify frost tolerant varieties that will yield high sucrose when harvested young, to facilitate more profitable sugarcane production in frost pockets. The objective of this study was to evaluate the performance of two fast-maturing varieties (LCP 85-384 and HOCP 96-540) imported from Louisiana, USA, known to yield high sucrose when young (Dufrene and Tew, 2004; Eggleston *et al*., 2004), and two South African varieties (N21 and N36) under typical frost-prone growing conditions in the Midlands.

Materials and Methods

All varieties were bulked-up using the NovaCane® tissue culture protocol (Snyman *et al*., 2008). A field trial was planted on 18 October 2007 in a typical valley-bottom frost pocket at New Hanover on Rudolph Koch's farm Green Hill in the Midlands North region of Kwazulu-Natal. The trial consisted of five replicated plots for each variety, randomised according to soil characteristics. Trial plots were comprised of five cane rows, each 10 m long, spaced 1 m apart. Trial management proceeded as per farm practice.

Stalk samples were taken from each plot prior to frost events to determine sucrose content (%). The first light frost occurred during mid-June 2008 and was followed by heavier frosts between 26 June and 3 July 2008. The heaviest frost occurred on 11 July 2008. Cane yield (t/ha) and sucrose content (%) were subsequently determined at harvest on 23 July 2008.

For a physiological assessment of frost effects on the varieties, fast polyphasic fluorescence transients (Strasser and Govindjee, 1992) were recorded in the youngest fully-expanded leaves with a fluorescence meter (PEA, Hansatech Instruments Ltd, King's Lynn, Norfolk, PE 30 4NE, UK). The data were used to calculate the Performance Index (PI_{ABS}) (Strasser *et al*., 2000), which is a reliable indicator of electron transport efficiency and photosynthetic capacity during low temperature stress (Strauss *et al*., 2007). Chlorophyll fluorescence measurements were started six weeks before the first frost and repeated at 2-week intervals until harvest.

Results and Discussion

In Figure 1, the PI_{ABS} values recorded in the varieties before the first frost (black arrows), five days after the first frost (dark-grey arrows), and after several subsequent frosts (light-grey arrows) are shown. Although all varieties showed a decline in PI_{ABS} values following the first frost event, N36 and LCP 85-384 maintained these these slightly depressed values for at least two weeks, even following several additional frosts (Figure 1A). In varieties N21 and HOCP 96-540, on the other hand, additional frosts led to a large decline in PI_{ABS} values (Figure 1B). Ultimately, the most severe frost event that occurred just prior to harvest led to high levels of damage in all varieties. Maintenance of electron transport capacity for at least two weeks after the first frost indicates potential for cold acclimation in N36 and LCP 85-384. These results depict a typical example of stress acclimation where exposure to a light frost hardens the plants to better tolerate subsequent heavier frosts, hence enabling sustained sucrose production for longer. The potential for cold acclimation in plants having the C_4 photosynthetic pathway was recently demonstrated (Kakani *et al*., 2008), and in sugarcane varieties the ability to cold acclimate might be related to sensitivity of pyruvate, orthophosphate dikinase (PPDK) and NADP-malate dehydrogenase (NADP-MDH) activity (Du *et al*., 1999).

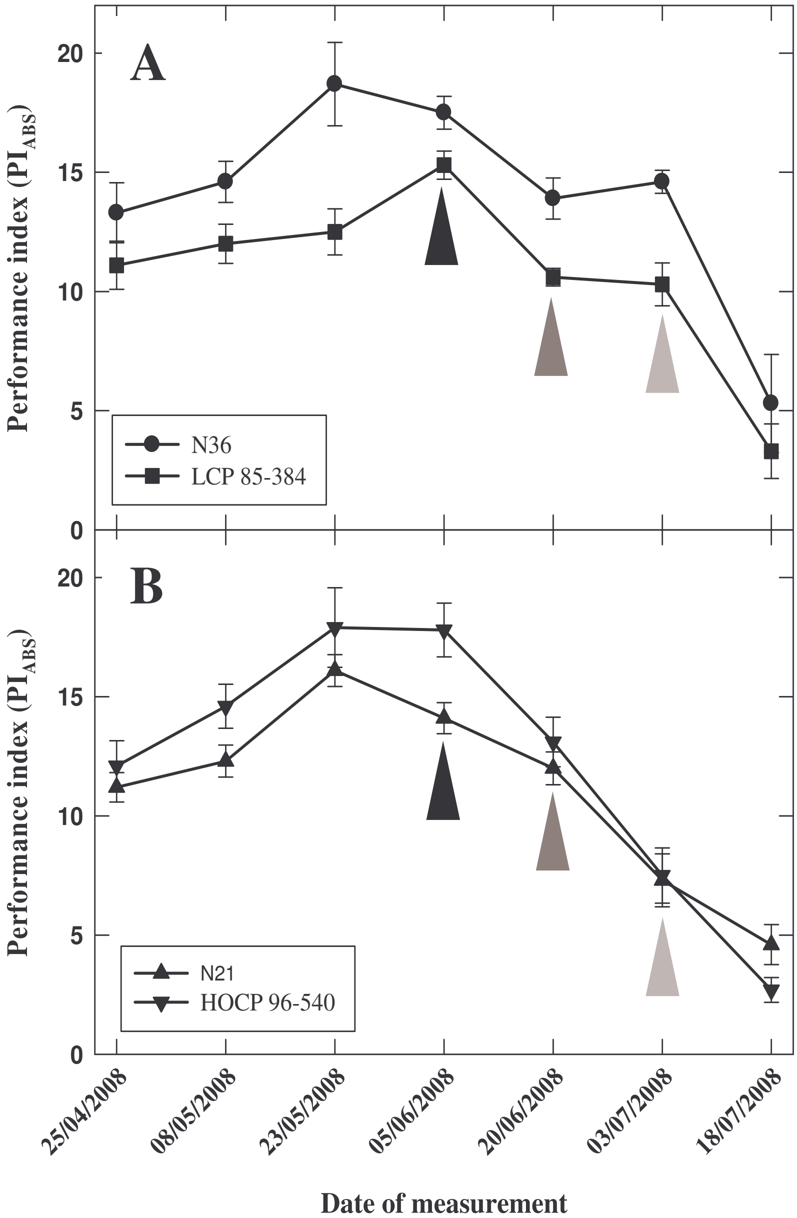

Figure 1. The effect of frost on Performance Index (PI$_{ABS}$) values in four sugarcane varieties. Values represent the mean of five replicates ± SEM.

The impact that cold acclimation potential had on cane quality was determined by comparing stalk sucrose contents (%) before the onset of the first frost with those obtained at harvest. This comparison revealed that N36 and LCP 85-384, which did cold acclimate, increased stalk sucrose content significantly more than N21 and HOCP 96-540, which did not cold acclimate (results not shown). From various trials performed in the United States, it is known that HOCP 96-540 usually yields higher sucrose than LCP 85-384 (Dufrene and Tew, 2004). In the South African trial this was the case before the first frost, but at harvest HOCP 96-540 lost this advantage (results not shown).

Although N36 and N21 had similar cane yields at a crop age of nine months (results not shown), N36 yielded 30% higher sucrose (t/ha) than N21 (Figure 2).

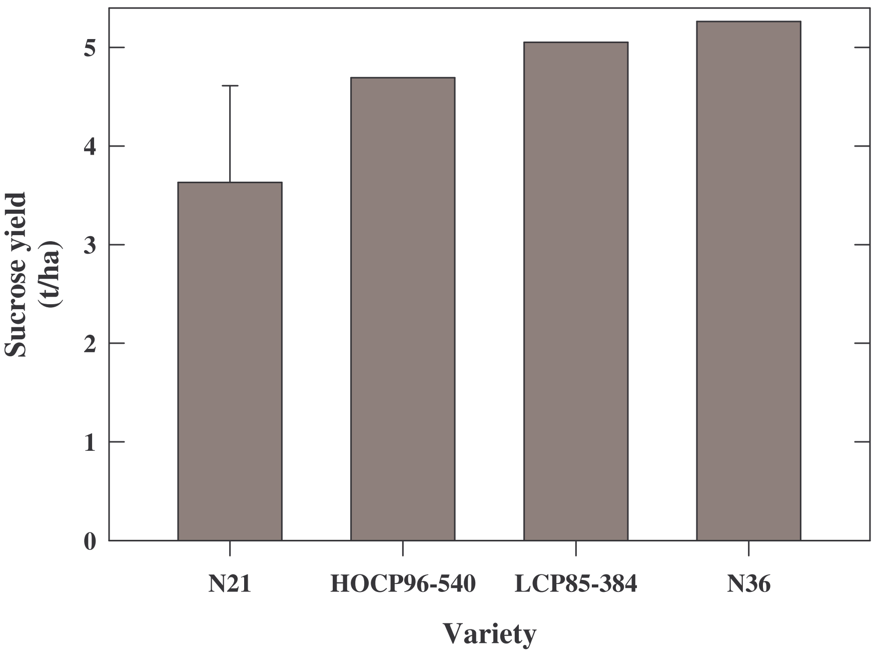

Figure 2. Sucrose yields of nine-month old sugarcane varieties grown in a frost pocket in the Midlands region of KwaZulu-Natal province in South Africa. Values represent the mean of five replicates, with the error bar indicating $LSD_{0.05}$.

A similar yield difference between varieties N36 and N21 was observed in a separate frost trial at a different location (Ramburan, 2008). Although HOCP 96-540 and LCP 85-384 had similar cane yields (results not shown), the known sucrose yield advantage of HOCP 96-540 over LCP 85-384 (Dufrene and Tew, 2004) was reversed (Figure 2). The ability to maintain high sucrose accumulation capacity for longer following frost could be an important factor determining yield performance under these conditions. In conclusion, the varieties N36 and LCP 85-384 showed potential for use in frost pockets due to their cold acclimation ability and higher sucrose yields, even at a young plant crop age of nine months. During the next winter, the yield responses of these varieties will be determined at a crop age of 12 months.

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