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学　位　論　文　題　名

Chilling tolerance and biomass production of *Saccharum* × *Miscanthus* intergeneric hybrids (miscanes) in cool climatic conditions of northern Japan
(北日本の冷帯気候条件でのサトウキビ属×ススキ属の属間雑種（ミスケーン）の低温耐性とバイオマス生産)

Sugarcane is cultivated on 26.7 mha and yields nearly 1.9 billion metric tons per year with a peak dry matter yield >100 tons (ha yr^{-1}). In addition to being the leading sugar-producing crop for human consumption, sugarcane is also used as a lignocellulosic biomass and a feedstock for bioethanol production. However, the lack of environmental adaptation of sugarcane has been a persistent problem, especially owing to its susceptibility to cold. *Saccharum* can be crossed with related genera belonging to so-called "*Saccharum* complex", which includes *Miscanthus*, *Erianthus*, or other genetically similar grasses. *Miscanthus*, a native C_4 grass of East-Asia is receiving a lot of focus in recent years as a potential genetic resource, especially to improve cold tolerance in sugarcane. *Miscanthus* was reported to produce shoots at a temperature as low as 6 °C and survive after prolonged exposure to temperatures <-6.5 °C. True hybrids of *Saccharum* and *Miscanthus*, often termed as miscane, have been recently obtained. The aim of the present study is 1) to observe genotypic variability of miscane in photosynthesis and biomass traits that will ensure important selection criteria to improve sugarcane; 2) to test chilling tolerance in miscane compared to its parents which will confirm the introgression of chilling tolerance traits into sugarcane from *Miscanthus*; 3) to test the biomass production capacity of miscane genotypes as a potential biomass energy crop in cool regions.

Eighteen miscane genotypes, derived from intergeneric hybridizations between two genotypes of sugarcane and two genotypes of *Miscanthus* (one each of *M. sinensis* and *M. sacchariflorus*) were used to screen for chilling tolerance. In a greenhouse experiment on long-duration chilling stress (12–13 °C day / 7–9 °C night), seven miscane genotypes exhibited higher photosynthetic rates than

their sugarcane parents after seven days of chilling, whereas after 14 days only four miscanes had significantly higher photosynthetic rates than their sugarcane parents, but notably two of these did not differ from their highly tolerant *Miscanthus* parents. The results indicated variability in chilling tolerance in miscanes, thus selection will be a key aspect of improving chilling tolerance in sugarcane.

In three subsequent growth-chamber experiments to evaluate chilling stress and post-chilling recovery, four miscane genotypes representing the range of responses observed in the greenhouse experiment were compared with their parents. After short-term and long-term chilling stresses of different temperatures, the miscanes retained more of their pre-chilling photosynthetic rate compared to their sugarcane parents, with some of the genotypes not significantly different from their *Miscanthus* parents. After one and seven days of post-chilling recovery, the *Miscanthus* and miscanes fully recovered their pre-chilling photosynthetic rates but the sugarcane parents did not. These experiments confirmed that genes from *Miscanthus* can be used to improve chilling tolerance of sugarcane via introgression.

In addition, field experiment trials evaluated that several miscane genotypes have high early- and late-season photosynthesis coupled with high biomass production, likely indicating chilling tolerance. High broad-sense heritabilities for traits including stem diameter, tiller number, leaf width, leaf and stem dry weight, and high correlations between these traits and dry matter yield indicated that selections can be made efficiently to improve sugarcane. Miscane 'JM 14-09' was identified as a superior genotype for introgression breeding programs.

The present study is the first of its kind report which elucidated genotypic variability, chilling tolerance and biomass production of *Saccharum* × *Miscanthus* intergeneric hybrids under cool climate of northern Japan and compared them to their parental genotypes. Chilling tolerance and high biomass potential under cool temperature were identified in miscane. As mentioned above, the present study could provide an important insight for researchers interested in studying sustainable biomass production of sugarcane.

In addition to the excellent academic knowledge in the research, his academic records throughout the Ph. D course are excellent. Based on these evidences, the committee reached to a conclusion that Kar Suraj deserves to become a Doctor of Environmental Science.