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An-Overview on invertase in sugarcane

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Abstract:
Saccharum officinarum is one of the most cultivated hybrid varieties among the sugarcane varieties. In sugarcane plant sucrose is the major carbohydrate which can be stored and transported. Different physiological and biochemical studies on this crop report that invertase activity and sucrose concentration some how are key limiting step in the process of sucrose accumulation. Significant efforts have been made in relation to the sucrose cycle by altering the sucrose phosphate synthetase, sucrose synthetase and invertase. In sugarcane two types of invertase enzymes have been reported on the basis of pH and cellular localization. Invertase breaks the sucrose into hexoses as a source of energy and carbon. It has also been reported that this enzyme is involved in the process of cell differentiation and plant development. Progress has been made for the understanding of invertase activity and its role in sugarcane plant. With the help of biotechnology it is possible to target the desired gene with genetic engineering approach to increase sucrose content by careful manipulation of invertase (enzyme) gene to increase the sucrose yield in sugarcane. Purpose of this mini review is to high-light the role of invertase in sugarcane and how to overcome sucrose recovery in sugarcane.

Keywords: Sugarcane, Invertase, Sucrose metabolism, Differentiation, Development.

Background:
Sugarcane is cash crop and primary use of this crop is to produce sucrose. It has been reported that almost 70% of the sugar used through out the world is derived from the sugarcane **[1, 2]**. Sugarcane belongs to the family poaceae (C4 Plant) and is able to accumulate up-to 25% (w / w) of fresh weight in the form of sucrose under normal growth conditions **[3].** This is the only crop plant having large amount of sucrose storing capacity. Sugarcane varieties can store sucrose in higher concentration as that can be crystallized in the form of sugar. Increases in sugar (sucrose) have been achieved by the conventional breeding programme which led to improve in cane yield not in sugar content **[4]**. It has been investigated that invertase enzyme plays important role in sucrose hydrolysis so role of invetase activities is very important **[5].** In sugarcane crop invertase enzymes play an important role in cellular mechanism process and direct the utilization of carbohydrates for the growth or storage. Invertase enzymes have been characterized in several plants and have been reported that these play important role in growth, development and storage of sugars in the plants **[6, 7]**. Invertases in plants have been classified as neutral, acid or alkaline on the basis of pH range that is required for the maximum activity of enzyme. In sugarcane two types of this enzyme have been reported on the basis of pH (acid invertase pH 5.0-5.5 and neutral invertase pH 7.0) and cellular localization. Role played by this enzyme in sucrose metabolism have been elucidated by several scientists **[8]**.

Role of invertase in metabolism
In sugarcane invertase cleave sucrose in the hexoses to provide the cell with fuel for the process of respiration and energy and carbon source for the synthesis of different compounds. In sugarcane plant sucrose starts accumulation in internodes when they start elongation till elongation achieve to maximum **[9]**. In the ripening stage sucrose concentration increased and glucose and fructose concentrations at very low level **[10]**. Invertase enzyme play important role in sucrose metabolism with sucrose phosphatase synthetase and sucrose synthetase enzymes. This enzyme involve in the transport of sucrose by balancing the sucrose concentration of phloem loading and unloading **[11]**. Invertase break down the sucrose into glucose and fructose as a result increase in osmotic pressure of cells, so this play role in cell elongation and growth process **[12]**. It has been reported that in sugarcane plants the amount of invertase in immature

intermodal tissue was linearly related to the rate of intermodal elongation process that may rise to even ten fold **[12]**. Further it has been reported that soluble acid invertase present in vacuole and apoplastic space of elongating internodes, and this disappear when intermodal growth stopped and again reappeared when growth started. The neutral invertase have been reported with increased level during maturation process as this play role is in storing the sugar at mature stage **[13]**. It is also have been reported that acid invertase lacking in mature sugarcane tissue **[14]**. Different varieties of sugarcane vary in the potential of accumulation of sucrose. It has reported sharp decline in the acid invertase with the maturity of sugarcane related with the higher level of sucrose in the sugarcane varieties those mature early **[15]**. But with late maturing varieties decline in the acid invertase was slower **[16, 17]**. In other crops also high acid invertase has been reported in growing tissues of carrot **[18]** stem elongation of bean **[19]** the reason acid invertase hydrolyzed the sucrose where there is high demand of hexose sugars. Invertase also play important role in regulation of cell turger for the cell expansion and sugar composition in storage organ **[20, 21, 22]**.

Role of invertase in sucrose storage

Sucrose storage is a process in which there is continuous cleavage and synthesis of sucrose in the sucrose accumulation process **[23]**. In the immature tissue of sugarcane sucrose synthesis achieved is degraded by the acid invertase enzyme but during the ripening process production rate of sucrose is almost twice and hydrolysis by the acid invertase also decreased **[14]**. It has reported that at immature stage of sugarcane the import of carbon from phloem to the internodal consumed for the growth but during ripening process almost half of carbon is consumed for the storing of sucrose **[24]**. It has been reported that soluble acid invertase activity decreases **[16, 8]**, and neutral invertase activity increases on increases with tissue maturation and sucrose accumulation **[16, 8]**. Decrease of soluble acid invertase and elevation of neutral invertase activities with different sugarcane tissue maturation varieties was observed high sucrose accumulation **[15]**. It has been reported that neutral invertase activity positively correlated with hexose sugars levels in the stalk of sugarcane while soluble acid invertase did not have any correlation **[8]**. The storage sucrose is metabolized by the invertase enzyme (sucrose cleaving enzyme) have multiple functions that effect different physiological process [**25**]. Invertase enzyme also involved in the long distance transport of sucrose for sucrose storage through generating the sucrose concentration between the sites of phloem unloading and loading [**26, 12**].

Conclusion:

To increase the sucrose in sugarcane it is very important to control the invertase. Strategy to increase the concentration of sucrose in sugarcane plant needs a through understanding of role of invertase and transgenic manipulation of invertase gene which is involved in sucrose accumulation. Antisense approach or gene suppression can be attempted to target expression of invertase which will control the level of hexoses and enhance sucrose storing in sugarcane varieties. Several biochemical and physiological studies on sugarcane invertase activity have reported it as a key step in the sucrose accumulation process. Further down regulation of invertase in spatiotemporal manner may be targeted by the RNAi approach. Reduction in the sugarcane invertase activity using the post-transcriptional gene silencing approach may be very useful in controlling the sucrose loss at post-harvest stage. Use of stage and tissue specific promoter can be exploited to express the antisense RNA (ds RNA) for invertase in later stages, which would reduce the invetase level thereby presenting the catabolism of sucrose. In my opinion plant physiologist, biochemist and molecular biologist should work together to overcome this problem. The idea has tremendous potential and if seriously looked upon may resolve the problem of post harvest sucrose loss to a greater extent.

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References:

[1] Lakshmanan P *et al*. *In Vitro Cell Dev Biol Plant.* 2005 **41**: 345
[2] Carson DL *et al. Plant Sci.* 2002 **162**: 289
[3] http://books.google.co.in/books?id=Dv-ZvJuIC2UC&dq=Sugarcane:photoassimilate+Distribution+in+plants&hl=en&sa=X&ei=8laTUd38AYKHrAfYj4HADQ&ved=0CC4Q6AEwAA
[4] Jackson PA, *Field Crops Res*. 2005 **92**: 277
[5] Vorster DJ & Botha FC, *Phytochem.* 1998 **49**: 651 [PMID: 9779590]
[6] Stommel JR & Simon PW, *Phytochem.* 1990 **29**: 2087
[7] Krishan HB *et al. Plant Physiol.* 1985 **78**: 241 [PMID: 16664223]
[8] Gayler KR & Glasziou KT, *Physiol Plant.* 1972 **27**: 25
[9] Lingle SE & Smith RC, *Crop Sci.* 1991 **31**: 172
[10] Fernandes AC & Benda GTA, *Int Sugarcane J.* 1985 **5**: 8
[11] Eschrich W, *Ber Dtsch Bot Ges.* 1980 **93**: 363
[12] Gibeaut DM *et al. Plant Physiol.* 1990 **94**: 411
[13] Sachdeva M *et al. Acta Physiologia Plant.* 2011 **33**: 1571
[14] Hawker JS & Hatch MD, *Physiol Plant.* 1965 **18**: 444
[15] Batta SK & Singh R, *Phytochem.* 1986 **25**: 2431
[16] Terauchi T *et al. Jpn J Trop Agric.* 1999 **43**: 271
[17] Sachdeva M *et al. Sugar Tech.* 2003 **5**: 265
[18] Ricardo CPP & Ap Rees T, *Phytochem.* 1970 **9**: 239
[19] Morris DA & Arthur ED, *J Exp Bot*. 1985 **6**: 623
[20] Perry CA *et al. Planta* 1987 **170**: 353
[21] Meyer RF & Boyer JS, *Planta*. 1981 **151**: 482
[22] Klann EM *et al. Plant Physiol.* 1993 **103**: 863
[23] Whittaker A & Botha FC, *Plant Physiol.* 1997 **115**: 1651
[24] Komor E, *Carbohydrate reserves in plants: synthesis and regulation. Elsevier, Amsterdam,* 2000 pp 35–53.
[25] Sturn A & Tang GQ, *Trends Plant Sci*. 1999 **4**: 401 [PMID: 10498964]
[26] Sturm A, *Plant Physiol.* 1999 **121**: 1

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