Determining Breakeven Third Stubble Sugar Yields to Economically Optimize Sugarcane Crop Cycle Length

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ABSTRACT

Determination of the optimal sugarcane crop cycle length is a critical factor related to maximizing net economic returns from sugarcane production. Crop cycle length decisions involve tradeoffs between acreage devoted to crop production of different ages, with the associated differences in expected yields and production costs along with the related impacts on total farm sugarcane acreage. The purpose of this study was to identify a decision rule which could be used in evaluating third stubble sugarcane crops for production. An economic model was developed to estimate breakeven third stubble sugar yields required to equate total crop cycle net returns through harvest of a second and third stubble crop. Research results indicated that in order to keep a third stubble crop in production to maximize crop cycle net economic returns, the third stubble sugar yield must be at least approximately 75% of the average yield of the preceding three crops. Factors such as changes in raw sugar price, planting ratio, land rent charge and harvest costs were found to have only minor impacts on this breakeven relationship.

INTRODUCTION

Maximization of net economic returns from sugarcane production is dependent upon several agronomic and economic factors. High-yielding varieties are of primary importance to ensure positive net farm returns and to maintain the long-run economic viability of a sugarcane farming operation. Sugarcane variety yield, and more specifically yields of stubble crops, significantly influences the economically optimal length of the crop cycle. The determination of optimal sugarcane crop cycle length is also a critical production decision which directly affects farm net returns. As a sugarcane crop cycle is extended for another year of production, there are tradeoffs between farm area devoted to sugar production and farm area devoted to fallow and seed cane expansion. As a result, the crop cycle length chosen involves tradeoffs between
changes in total farm revenues and changes in total crop production expenses. The purpose of
the research results presented here is to identify a farm management production decision rule
which can be used to determine the economically optimal crop cycle length for tracts of land in
sugarcane production.

The distribution of sugarcane area in Louisiana across crop ages is shown in Table 1 for
the past twelve years. Although these area distribution percentages are calculated over total
sugarcane hectares in the state, and not for an individual farm, evaluation of the distribution over
time can give some indication of average economically optimal crop cycle lengths as sugarcane
crop net returns change over time due to changes in yields, market prices and production costs.
For crop cycles with harvest through a third stubble crop, sugarcane area would be distributed
equally to plant cane, first stubble, second stubble and third stubble land tracts. This was the
case in 2002 through 2005, where approximately the same amount of sugarcane area was in each
stage of production. However, over the past five years the average sugarcane area distribution
has changed, with higher percentages in plant cane through second stubble crops and lower
percentages in third and older stubble. Recent area estimates suggest that only about half of the
second stubble area is kept in production the following year with the other half being plowed out
for replanting. Being able to estimate the potential sugar yield of a third stubble sugarcane crop
required to maximize net farm returns over the entire crop cycle is important information to aid
production decisions on these older stubble crops.

Perennial crop production has been studied across a number of crops, with several
optimization methodologies considered. According to French and Matthews (1971), perennial
crop production is distinguished from the production of annual crops by (a.) the long gestation
period between initial input and first output, (b.) extended period of output flowing from the
initial production or investment decision, and (c.) eventually a gradual deterioration of the
productive capacity of the plants. Thus, a perennial crop model must explain not only the
planting process but the removal and replacement of plants and must explicitly consider the lags
between input and output and the effects of populations of bearing plants on production.
In a study related to optimal replacement time of perennial crops, the authors argued that maximum sustainable yields (MSY), rather than more commonly utilized net present values (NPV), often need to be considered for policy (Tisdell and De Silva, 2008). While the NPV approach is valuable, it requires a considerable amount of information about prices and interest rates and more calculation than MSY. Despite these affirmations, economists have been critical of the MSY approach proposed by many forest industry sectors arguing that the optimal length of replacement cycle based upon the MSY usually will differ from that indicated by the NPV approach (Tisdell and De Silva, 2008).

According to Knapp (1987) perennial crop planting decisions must weight costs and returns over time spans from three to five years for some hay crops to more than forty years for some tree crops. In addition, annual yields and input requirements typically vary over the life of the crop. This implies that the optimal rotation length and hence the age composition of the crop will vary over time depending on the price of output and prices of inputs including land and other factors (Knapp, 1987). According to Rae (1970) perhaps the simplest approach to capital budgeting problems is to determine the present value of future cash flows, the internal rate of return or the payback period for each of the alternative investment projects. However, such approaches are not applicable if (a.) the investment projects are interdependent, complementary or competitive, (b.) projects complement each other with respect to cash supplies or (c.) projects have multiple uses. In the case of sugarcane production, the interrelationship of land in older stubble and land being fallowed for planting as well as the impacts of the production decision for one land tract affecting area availability on other land tracts on the farm prevent the use of a simplistic net present value approach which considers individual land tract production decisions as independent of each other. In order to handle such problems, programming techniques have been employed by some researchers. Earlier studies proposed the use of dynamic programming to determine optimal replacement strategies for perennial crop production (Loftsguard and Heady, 1959; Candler, 1960). Arguing a lack of realism in optimal replacement analyses that assume constant prices and yield patterns over time, Etherington (1977) proposed a stochastic model to deal with the problem of replacing an asset which continues to produce by a new asset whose future income stream is uncertain.
An early sugarcane study which determined a model of the stubble replacement decision for Florida sugarcane growers stated that the replacement decision depends on expected future values; therefore it is necessary to predict, in some manner, future yields for the current stubble crops as well as for the potential replacements (Crane and Spreen, 1980). A replacement analysis consists of two separate operations. The first is the selection of the “challenger”, that is to say, the best unit available for the replacement of the “defender”; the second is the determination whether the challenge is valid, in other words, whether the defender is presently replaceable (Crane and Spreen, 1980). The decision rule stated by this study is analogous of the replacement principle for the continuous case first proposed by Faris (1960) and later discussed by Perrin (1972); the rule is to replace if the average net returns from the “challenger” exceeds the net returns realized if the “defender” is kept another year.

Two earlier studies evaluated sugarcane replacement strategies for Louisiana varieties. One study estimated annualized net present values to compare alternative crop cycles for production of sugarcane varieties over the 1991-1994 period (Salassi and Milligan, 1997). Results indicated that average yield across plant cane, first and second stubble crops had a greater impact on third stubble production decisions than the relative yield decline from the plant cane crop in the first and second stubble crops. Another study determined the optimal number of sugarcane stubble crops to harvest which would maximize net returns for major sugarcane varieties in Louisiana. It was reported that for the three most widely cultivated sugarcane varieties in Louisiana in 2001, CP 70-321, LCP 85-384 and HoCP 85-845, the net returns would be maximized for all three varieties by extending the crop cycle length through at least third stubble harvest (Salassi and Breaux, 2002). It was stated that the economically optimal sugarcane crop cycle length is one which maximizes average net returns per acre over entire crop cycle. A decision rule which can be used to evaluate older stubble would state that a stubble crop should be kept for harvest only in the net returns for that crop would increase the average net returns over the crop cycle. The decision whether to keep current fields of older stubble in production include the impact of varying sugar prices, costs of production and sugarcane yields (Salassi and Breaux, 2002). This study, however, only evaluated optimization of net returns on a single tract of land, and did not evaluate the whole-farm implications of seed cane expansion requirements for crop cycles of different lengths.
MATERIALS AND METHODS

Methodology for this research study involved the development of an economic return model for sugarcane production which encompassed the acreage relationships for seed cane and production cane across various phases of production as well as the estimation of net returns above variable production costs over the entire crop cycle, taking into account changes in required seed cane area and area harvested for sugar for alternative crop cycle lengths. The primary objective of the research project was to identify a decision rule related to the evaluation of third stubble production which could be applied across a wide range of sugarcane varieties and soil types.

For a crop cycle length through harvest of a second stubble crop (total of three harvests before replanting) on a farm with a specified total farm acreage ($TFA = x$), total farm area devoted to fallow and planting operations each year was determined as follows:

$$FLW = TFA \times 0.25$$

$$CSCPLT = FLW/(1+(2*PR1) + (2*PR1*PR2))$$

$$TAHPLT = CSCPLT \times (1+2*PR1)$$

$$TAMPLT = 2 \times CSCPLT \times PR1 \times PR2$$

$$TAPLT = TAHPLT + TAMPLT$$

where $FLW$ is total farm area in fallow, $TFA$ is total farm area in hectares, $CSCPLT$ is total hectares of cultured seed cane planted, $PR1$ is the planting ratio for the first seed cane expansion, $PR2$ is the planting ratio for the second seed cane expansion, $TAHPLT$ is the total area hand planted, $TAMPLT$ is the total area machine planted, and $TAPLT$ is total area planted. Total area hand planted and mechanically planted is differentiated to reflect differences in planting cost per hectare. Farm area harvested under this crop cycle was defined as follows:

$$PCHVSD = CSCPLT \times (1+2*PR1)$$

$$PCHVSG = 2 \times CSCPLT \times PR1 \times PR2$$

$$PCHV = PCHVSD + PCHVSG$$

$$ST1HVSD = CSCPLT$$

$$ST1HVSG = 2\{((CSCPLT \times PR1) + (CSCPLT \times PR1 \times PR2))\}$$

$$ST1HV = ST1HVSD + ST1HVSG$$

$$ST2HVSG = ST1HVSD + ST1HVSG$$

$$ST3HVSG = 0$$

$$TFA = TAPLT + PCHV + ST1HV + ST2HVSG$$
where \( PCHVSD \) is the plant cane hectares harvested for seed cane, \( PSCHVSG \) is the plant cane hectares harvested for sugar, \( PCHV \) is total plant cane area harvested, \( ST1HVSD \) is the first stubble hectares harvested for seed cane, \( ST1HVSG \) is the first stubble hectares harvested for sugar, \( ST1HV \) is total first stubble hectares harvested, \( ST2HVSG \) is the second stubble hectares harvested for sugar and \( ST3HVSG \) is the third stubble hectares harvested for sugar.

With a change in crop cycle length to harvest through a third stubble crop (four harvests prior to replanting), equations in the above total farm area model changed to:

\[
FLW = TFA * 0.20 \quad (1a)
\]
\[
ST3HVSG = ST2HVSG \quad (13a)
\]
\[
TFA = TAPLT + PCHV + ST1HV + ST2HVSG + ST3HVSG \quad (14a)
\]

The farm area model outlined above adjusted the required areas devoted to seed cane expansion to the revised value, in this case 20% of total farm area. Using the above model, economically optimal crop cycles through harvest of second and third stubble crops was evaluated by determining breakeven third stubble yields to keep area in production while incorporating the impacts of changes in whole farm planted and harvested area on net returns.

Table 2 shows two possible land area distributions of a 1000-hectare sugarcane farm operation harvesting through second stubble and through third stubble. As was previously mentioned, total farm area in fallow represents 25% of the total farm area for a crop cycle length through harvest of a second stubble crop; however it represents 20% of the total farm area for a crop cycle length through harvest of third stubble. In general, land distribution among different crop stages in a whole farm depend on how many stubble crops are kept in production.

To determine the breakeven third stubble sugar yield per hectare in evaluating the optimal crop cycle length, whole farm net returns above variable costs for a crop cycle through harvest of second stubble \( (NRAVC_{hv2}) \) were set equal to whole farm net returns above variable costs through harvest of third stubble as shown below:
NRAVC_{Hv2} = ((Y_{pc}AH_{pc}) + (Y_{1st}AH_{1st}) + (Y_{2st}AH_{2st}) + (Y_{3st}AH_{3st})) * MP_{sug} * GS_{sug}
- ((A_{fl}VC_{fl}) + (A_{cscp}VC_{cscp}) + (A_{hplt}VC_{hplt}) + (A_{mplt}VC_{mplt}) + (A_{pc}VC_{pcfo})
+ (A_{1st}VC_{1sfo}) + (A_{2st}VC_{2sfo}) + (A_{3st}VC_{3sfo}) + (A_{hv}VC_{hv})) \quad (15)

where \(Y_{pc}, Y_{1st}, Y_{2st}, \) and \(Y_{3st}\) represents the sugar yield per harvested hectare on production cane sent to the mill (plant cane through third stubble), \(AH_{pc}, AH_{1st}, AH_{2st}, \) and \(AH_{3st}\) represents the respective area of production cane harvests, \(MP_{sug}\) represents the market price of raw sugar, \(GS_{sug}\) represents the grower share to total sugar production, \(A_{fl}, A_{cscp}, A_{hplt}, A_{mplt}, A_{pc}, A_{1st}, A_{2st}, A_{3st}, \) and \(A_{hv}\) represents the farm area devoted to fallow, cultured seed cane planting, hand planting, machine planting, plant cane, first stubble, second stubble, third stubble and harvest, respectively, and \(VC_{fl}, VC_{cscp}, VC_{hplt}, VC_{mplt}, VC_{pc}, VC_{1st}, VC_{2st}, VC_{3st}, \) and \(VC_{hv}\) represent the variable production costs on those respective land area tracts. After simplifying the latter portion of the equation to whole farm variable costs for harvest through third stubble \(VC_{Hv3}\), the relationship was solved for the breakeven sugar yield per hectare for the third stubble crop \(Y_{3st}\), obtaining a final relationship as follows:

\[
Y_{3st} = \frac{[NRAVC_{Hv2} - ((Y_{pc}AH_{pc}) + (Y_{1st}AH_{1st}) + (Y_{2st}AH_{2st})) * MP_{sug} * GS_{sug} + VC_{Hv3}]}{(MP_{sug} * GS_{sug} * AH_{3st})} \quad (16)
\]

This breakeven equation was the basis of this analysis, providing the ability to estimate breakeven yields for third stubble sugarcane crops in determining optimal crop cycle lengths and the ability to evaluate the impact of factors such as yield level, raw sugar market price, diesel price, planting ratio and other factors on this decision rule. As a farm management decision rule, this estimated third stubble breakeven yield would be the sugar yield necessary to keep third stubble in production which would equate total crop cycle net returns above variable costs for crop cycles terminating with harvest of the second stubble and third stubble crops.

Sugarcane yield data, in kilograms of sugar per hectare harvested, utilized in this study were taken from the Outfield Variety Trials conducted over a range of locations across the Louisiana sugarcane production area. Sugar yields for major varieties evaluated over the 2008-2011 period were utilized in determining breakeven sugar yields for third stubble crops. Projected sugarcane variable production costs and returns for the 2012 crop year were used to
determine net returns over alternative crop cycles (Salassi and Deliberto, 2012). A raw sugar market price of $0.154 per kilogram was used to value the grower’s share of raw sugar production. Since estimated breakeven third stubble yield relates production expenses paid by the grower to raw sugar revenue received by the grower, only the grower’s share of total production value is included in the breakeven yield determination.

**RESULTS AND DISCUSSION**

Plant cane through third stubble sugar yields from the Outfield Variety Trials for major Louisiana sugarcane varieties are shown in Table 3. Sugar yields for the plant cane crop averaged 10,506 kg ha⁻¹ across the seven varieties evaluated. First stubble yields averaged 9,822 kg ha⁻¹ (93.5% of the plant cane average). Second stubble yields averaged 8,310 kg ha⁻¹ (79.1% of the plant cane average). The critical factor in determining economically optimal crop cycle length for sugarcane production in Louisiana is the third stubble yield level relative to the preceding crop yields, particularly the plant cane yield. For the seven varieties evaluated in the Outfield trials, third stubble sugar yields averaged 7,763 kg ha⁻¹. This yield level was 73.9% of the plant cane yield average. However, third stubble yields relative to plant cane yields varied greatly across the seven varieties, ranging from a low of 57.7% for HoCP 96-540 to a high of 88.2% for L 01-299.

Based upon the observed sugar yields of the plant cane through second stubble crops, the breakeven third stubble yield was estimated for each variety using the relationship derived in equation 16 above. At this third stubble yield level, the total net returns above variable costs over a crop cycle through harvest of the third stubble crop would be equal to the total net returns over a crop cycle through harvest of the second stubble crop. If the actual third stubble sugar yield was greater than the estimated breakeven yield, total crop cycle net returns would be greater by keeping the third stubble crop in production for harvest. If the actual third stubble sugar yield was less than the estimated breakeven yield, total crop cycle net returns would be greater by plowing out the third stubble crop and replanting to start a new crop cycle.

Estimated breakeven third stubble yields for varieties evaluated in the outfield variety trials ranged from 6,601 kg ha⁻¹ for HoCP 96-540 to 7,397 kg ha⁻¹ for L 01-299. These
Breakeven yield estimates are directly related to the yields obtained on the prior three crops, hence the variation in breakeven yields stated in kilograms of raw sugar per hectare. However, stating the breakeven third stubble yield as a percentage value of the simple average of the plant cane through second stubble yields results in a relatively stable value. These breakeven percentages are listed in Table 3 in parentheses immediately following the breakeven third stubble yields in raw sugar per hectare. Although the breakeven sugar per hectare values varies by as much as 796 kg ha\(^{-1}\) across the seven varieties, breakeven third stubble yields, expressed as a percent of the preceding three-crop average yield, is approximately 73% for each variety.

This breakeven third stubble percentage relationship result is primarily due to the farm area relationships between seed cane area and production cane area. For a given raw sugar market price and a given set of variable production costs, this third stubble production decision rule stated in percentage terms is relatively stable for changes in sugar yield or production costs. To illustrate this point, the Outfield yields presented in Table 3 were adjusted downward to simulate typical yields observed on commercial farming operations. Plant cane through third stubble yields were adjusted down to an average commercially recoverable raw sugar level of 115 kg mt\(^{-1}\) which is approximately the state average in Louisiana for the 2011 sugarcane crop. These adjusted yields are shown in Table 4. Adjusted average yields across the seven varieties range from 8,581 kg ha\(^{-1}\) for plant cane down to 6,341 kg ha\(^{-1}\) for third stubble. As in Table 3, breakeven third stubble yields were estimated on both a sugar per hectare and percentage basis. Breakeven sugar per hectare values for third stubble yields were dependent on the corresponding plant cane through second stubble yields, ranging from 5,454 kg ha\(^{-1}\) for HoCP 96-540 to 6,105 kg ha\(^{-1}\) for L 01-299. Stating these breakeven yields as a percentage of the plant cane through second stubble yield average, values for all varieties were at a level of approximately 74%, similar to the percentage values for the original Outfield data. Although the sugar per hectare yields may vary across varieties, the breakeven third stubble yield stated in percentage terms again remains relatively stable.

Other factors which could impact the third stubble production decision were evaluated to determine their influence on the estimated breakeven third stubble yield. These factors included first and second seed cane expansion planting ratio (5:1 to 8:1), land rent crop share (one-fifth
and one-sixth shares), raw sugar market price ($0.127 to $0.163 per kilogram), and variable harvest cost ($370 to $494 per harvest hectare). Although each of these factors were found to influence breakeven third stubble yields, that influence was determined to be relatively minor. For a range of planting ratios, land rent charges, sugar prices and harvest costs, the breakeven third stubble yield varied only between 73% and 75% of the simple average of the preceding plant cane through second stubble crop yields. Therefore, research results suggest that a relatively stable decision rule for determining whether to keep third stubble sugarcane crops in production or plow out for replanting could be stated that the projected breakeven third stubble crop sugar yield must be at least 75% of the average yield of the preceding plant cane through second stubble crop yields.

In the spring of each year, a sugarcane grower has to make the decision to keep fields of older stubble in production for harvest later that year or to plow them out for replanting. This evaluation should be made on a field by field basis due to the differences across fields of older stubble related to stubble condition, stubble age and other factors. A projection should be made as to the potential sugarcane yield on older stubble fields. This yield projection is only a rough estimate of the yield potential, but its validity can be improved with a combination of visual inspection of regrowth along with stand population counts where applicable. The methodology presented in this article does not project the yield of third stubble, but rather estimates the required yield to keep the tract in production from an economic optimization standpoint based upon the prior yield history of the tract. Having this breakeven yield information will provide the sugarcane grower with additional information which can be utilized along with yield projection estimates in making the final decision of whether to keep a field of older stubble in production or to plow it out for replanting.

ACKNOWLEDGEMENTS

Partial funding for this research was provided by the American Sugar Cane League.

REFERENCES


Table 1 Louisiana sugarcane crop area distribution, 2000-2011.

<table>
<thead>
<tr>
<th>Crop Year</th>
<th>Plant Cane</th>
<th>First Stubble</th>
<th>Second Stubble</th>
<th>Third and Older Stubble</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>27.8</td>
<td>29.5</td>
<td>25.2</td>
<td>17.5</td>
</tr>
<tr>
<td>2001</td>
<td>23.6</td>
<td>28.8</td>
<td>28.5</td>
<td>19.1</td>
</tr>
<tr>
<td>2002</td>
<td>25.7</td>
<td>25.7</td>
<td>26.6</td>
<td>22.0</td>
</tr>
<tr>
<td>2003</td>
<td>23.7</td>
<td>24.6</td>
<td>24.8</td>
<td>26.9</td>
</tr>
<tr>
<td>2004</td>
<td>27.3</td>
<td>25.7</td>
<td>24.3</td>
<td>22.7</td>
</tr>
<tr>
<td>2005</td>
<td>29.6</td>
<td>27.5</td>
<td>22.9</td>
<td>20.0</td>
</tr>
<tr>
<td>2006</td>
<td>29.8</td>
<td>28.4</td>
<td>25.1</td>
<td>16.7</td>
</tr>
<tr>
<td>2007</td>
<td>31.3</td>
<td>30.3</td>
<td>27.3</td>
<td>11.1</td>
</tr>
<tr>
<td>2008</td>
<td>31.2</td>
<td>31.9</td>
<td>26.9</td>
<td>10.0</td>
</tr>
<tr>
<td>2009</td>
<td>27.8</td>
<td>31.9</td>
<td>29.5</td>
<td>10.8</td>
</tr>
<tr>
<td>2010</td>
<td>29.1</td>
<td>29.0</td>
<td>28.0</td>
<td>13.8</td>
</tr>
<tr>
<td>2011</td>
<td>31.0</td>
<td>29.4</td>
<td>25.9</td>
<td>13.7</td>
</tr>
</tbody>
</table>

Source: Louisiana Sugarcane Variety Surveys, LSU Agricultural Center.

Table 2 Total farm area distribution for harvest through 2\textsuperscript{nd} and 3\textsuperscript{rd} stubble.

<table>
<thead>
<tr>
<th>Farm area</th>
<th>Harvest through 2\textsuperscript{nd} stubble crop</th>
<th>Harvest through 3\textsuperscript{rd} stubble crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultured seed cane</td>
<td>0.41%</td>
<td>0.33%</td>
</tr>
<tr>
<td>1\textsuperscript{st} seed cane expansion planted</td>
<td>4.10%</td>
<td>3.28%</td>
</tr>
<tr>
<td>2\textsuperscript{nd} seed cane expansion planted</td>
<td>20.50%</td>
<td>16.40%</td>
</tr>
<tr>
<td>Plant cane harvested for seed</td>
<td>4.50%</td>
<td>3.61%</td>
</tr>
<tr>
<td>Plant cane harvested for sugar</td>
<td>20.50%</td>
<td>16.4%</td>
</tr>
<tr>
<td>1\textsuperscript{st} stubble harvested for seed</td>
<td>0.41%</td>
<td>0.33%</td>
</tr>
<tr>
<td>1\textsuperscript{st} stubble harvested for sugar</td>
<td>24.59%</td>
<td>19.67%</td>
</tr>
<tr>
<td>2\textsuperscript{nd} stubble harvested for sugar</td>
<td>25.00%</td>
<td>20.00%</td>
</tr>
<tr>
<td>3\textsuperscript{rd} stubble harvested for sugar</td>
<td>-</td>
<td>20.00%</td>
</tr>
<tr>
<td>Fallow/plant</td>
<td>25.00%</td>
<td>20.00%</td>
</tr>
<tr>
<td>Harvest for seed</td>
<td>4.91%</td>
<td>3.94%</td>
</tr>
<tr>
<td>Harvest for sugar</td>
<td>70.09%</td>
<td>76.07%</td>
</tr>
<tr>
<td>Total farm area</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
### Table 3 Third stubble breakeven sugar per hectare yields using actual research plot yields.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Plant Cane 2008-2011 (kg ha⁻¹)</th>
<th>First Stubble 2008-2011 (kg ha⁻¹)</th>
<th>Second Stubble 2008-2011 (kg ha⁻¹)</th>
<th>Third Stubble Breakeven yield² (kg ha⁻¹)</th>
<th>Third Stubble Breakeven yield² (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HoCP 96-540</td>
<td>10,296</td>
<td>9,311</td>
<td>7,436</td>
<td>5,943</td>
<td>6,601 (73.2%)</td>
</tr>
<tr>
<td>L 99-226</td>
<td>10,651</td>
<td>10,288</td>
<td>8,442</td>
<td>7,722</td>
<td>7,165 (73.2%)</td>
</tr>
<tr>
<td>L 99-233</td>
<td>10,586</td>
<td>9,129</td>
<td>7,889</td>
<td>7,413</td>
<td>6,728 (73.1%)</td>
</tr>
<tr>
<td>HoCP 00-950</td>
<td>10,578</td>
<td>9,291</td>
<td>7,796</td>
<td>7,789</td>
<td>6,744 (73.1%)</td>
</tr>
<tr>
<td>L 01-283</td>
<td>10,177</td>
<td>10,077</td>
<td>8,970</td>
<td>8,747</td>
<td>7,149 (73.4%)</td>
</tr>
<tr>
<td>L 01-299</td>
<td>10,260</td>
<td>10,823</td>
<td>9,167</td>
<td>9,048</td>
<td>7,397 (73.4%)</td>
</tr>
<tr>
<td>L 03-371</td>
<td>10,993</td>
<td>9,837</td>
<td>8,469</td>
<td>7,674</td>
<td>7,131 (73.0%)</td>
</tr>
<tr>
<td>Average</td>
<td>10,506</td>
<td>9,822</td>
<td>8,310</td>
<td>7,763</td>
<td>6,987 (73.2%)</td>
</tr>
</tbody>
</table>

¹ Stubble crop yield as a percent of plant cane yield.
² Percentage value equals 3rd stubble breakeven yield as a percent of the simple average yield of plant cane, 1st and 2nd stubble yields.

### Table 4 Third stubble breakeven sugar per hectare yields using adjusted farm level yields.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Plant Cane¹ 2008-2011 (kg ha⁻¹)</th>
<th>First Stubble¹ 2008-2011 (kg ha⁻¹)</th>
<th>Second Stubble¹ 2008-2011 (kg ha⁻¹)</th>
<th>Third Stubble¹ 2008-2011 (kg ha⁻¹)</th>
<th>Third Stubble Breakeven yield³ (kg ha⁻¹)</th>
<th>Third Stubble Breakeven yield³ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HoCP 96-540</td>
<td>8,410</td>
<td>7,605</td>
<td>6,074</td>
<td>4,854</td>
<td>5,454 (74.1%)</td>
<td></td>
</tr>
<tr>
<td>L 99-226</td>
<td>8,700</td>
<td>8,404</td>
<td>6,895</td>
<td>6,308</td>
<td>5,916 (73.9%)</td>
<td></td>
</tr>
<tr>
<td>L 99-233</td>
<td>8,647</td>
<td>7,457</td>
<td>6,445</td>
<td>6,055</td>
<td>5,559 (74.0%)</td>
<td></td>
</tr>
<tr>
<td>HoCP 00-950</td>
<td>8,640</td>
<td>7,589</td>
<td>6,369</td>
<td>6,362</td>
<td>5,572 (74.0%)</td>
<td></td>
</tr>
<tr>
<td>L 01-283</td>
<td>8,313</td>
<td>8,231</td>
<td>7,327</td>
<td>7,144</td>
<td>5,901 (74.2%)</td>
<td></td>
</tr>
<tr>
<td>L 01-299</td>
<td>8,380</td>
<td>8,840</td>
<td>7,488</td>
<td>7,391</td>
<td>6,105 (74.1%)</td>
<td></td>
</tr>
<tr>
<td>L 03-371</td>
<td>8,979</td>
<td>8,035</td>
<td>6,918</td>
<td>6,269</td>
<td>5,888 (73.8%)</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>8,581</td>
<td>8,023</td>
<td>6,788</td>
<td>6,341</td>
<td>5,770 (74.0%)</td>
<td></td>
</tr>
</tbody>
</table>

¹ Yields adjusted to an average 115 kg mt⁻¹ CRS.
² Stubble crop yield as a percent of plant cane yield.
³ Percentage value equals 3rd stubble breakeven yield as a percent of the simple average yield of plant cane, 1st and 2nd stubble yields.