Sensitivity comparison of the sugarcane mill delay in Iran.

Green sugar cane is more sensitive or burned?

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ABSTRACT

Sugarcane is one of the industrial crops used as raw material for several major and minor industries. In Khuzestan, which contains most of the sugarcane farms of Iran, sugarcane is harvested either in green or burnt method. Mechanized harvesting has been replaced by manual harvesting during recent years. Delay in milling of the harvested sugarcane is caused by different reasons in agro-industry units, in addition, methods of harvesting including green and burnt harvesting can cause qualitative and quantitative losses of canes. Thus, a split-plot in time design was executed, with the randomized complete block basic design in 5 replications, in Hakim Farabi agro-industry in 2015. The results showed that the interaction between time delay and harvesting method was significant in 5% level of probability in the main traits of sugarcane i.e. the amount of yellow and white sugar which is affected by other qualitative and quantitative factors. In such a way that the amount of yellow and white sugar during 5 days delay in burnt sugarcane was respectively 1.96 and 1.63 tons per each 100 tons, whereas the amount was 1.3 and 1.08 tons in green harvesting of sugarcane. Thus, compared to burnt sugarcane, green harvesting is less sensitive toward time delay. The invert, which represents loss of sugarcane quality, was separately significant in harvest and time treatments respectively in 1% and 5% levels of probability; in such a way that was 1.7 times higher in burnt sugarcane compared to green one day. The amount of invert in 5th day was 1.35 higher than 4th day.

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Introduction

The main product obtained from sugarcane is sugar the amount of which depends on variety and geographic and climatic conditions and normally is between 10% to 12%. In addition to use as human and livestock feed, fuel and energy production and chemicals production, sugar is also used in medical and other industries, cement, concrete, molding, metal melting, tannery, detergents, softeners and explosives (Shoushtari et al, 2007). The increasing worldwide demand for sugar (increase of capita consumption growth rate) on one hand and its application in ethanol production on the other hand has turned this product into a strategic commodity. Therefore, in order to achieve country’s developmental goals focusing on self-sufficiency in the production of basic products, the department of agriculture has concentrated on production improvement and reduction of waste during recent years (Mir Majidi et al, 2008). There are different definitions for “waste”:

General definition: including loss of energy, soil and agricultural products and other factors which interfere in produce, process, distribute and consume of materials in agriculture (Zare and Rezaie. 2009).

Specific definition: damages, actual and potential casualties of agricultural products (Sharifi joo, 2007).

Potential casualties consist of the difference between produced product and potential product that cannot be produced in the production process because of the lack of inputs and appropriate methods, environmental conditions, etc.

Actual casualties are the amount of products which, because of various reasons, will be out of the processing, storage, distribution and consumption cycle which will not be consumed e.g. falling of canes during sugarcane harvesting.

Residue is the amount of material which is inevitably produced in the production and processing cycle such as straw and stubble in grains and brushwood in sugarcane planting.

According to food balance sheet the amount of agricultural and livestock waste is growing with an increasing trend from 6818 tons in 2002 to 8025 tons in 2006 which shows 4.16% growth; and so the per capita waste has increased from 102.83 Kg in 2002 to 113.84 Kg in 2006 which shows 2.5% growth (Ebadie and saeednia, 2008). Decreasing of waste is directly related to increasing of supply, and in such way output can be obtained without additional input. So it can result in thrift and optimum use of natural and nonrenewable resources, such as sugarcane, e.g. with a 1% decrease of sugar waste (through improving the extraction efficiency) in milling process in a sugarcane factory (with the capacity of 10000 tons sugarcane per day) in an exploitation period (100 days), approximately 1000 tons additional sugar will be produced, which is equal to 150 hectare sugarcane with the yield of 67 tons/hectare and value of 10 billion rials (with the price of 10000 rials per Kg) (Anonymous, 2007). As a result, decreasing of waste, in addition to increasing of the productivity of production resources can lead to sustainable development in this field.

Mechanized harvesting of sugarcane

Mechanized harvesting is more expensive in countries with lower level of income and may cause some problems which
shouldn't be underestimated. Such problems include soil compaction and as a result crop losses and fewer amounts of ratoo and more sugarcane waste in the field. Delivery of the cleaned canes to the factory (cleaned cane means without leaf, head and soil), interruption in the harvesting operation at the time of heavy rainfall, etc (Madani and Noor Mohammadi, 2004); but time saving is the most important advantage of mechanized harvesting which causes to underestimate its disadvantages. Chopper harvesters are the most complicated sugarcane harvesting machines which applying them requires skill, accuracy and maintenance. Nowadays chopper harvesters are considered to be the best harvesters for sugarcane because they perform all of the harvesting operations together and despite their mentioned disadvantages, they have many advantages including increasing of the cane carrying basket capacity and thus decreasing of the production costs, labor force, diversity of machines, probability of remaining of the sugarcane in the field caused by harvest and loading concurrency, and also increasing of the sugarcane milling efficiency and improving of the extraction, delivery of the fresh sugarcane to the factory, etc (Shooshtari, 2007). Sugarcane is typically achieved in cold and dry parts. Increasing of the water stress leads to sucrose aggregation. Although most of the leaves are green but in ripe sugarcane most of the leaves are dry. Sugarcane harvesting in Khuzezenstan usually begins at the end of the October, while temperature degree decreases and plant's sucrose increases, and continues until the beginning of the April. After each harvesting, plant grows again and until next year it is ready to be harvested and unlike areas with hot climate, in Khuzezenstan sugarcane is harvested once a year. From each ton of harvested sugarcane in Khuzezenstan, 100 Kg of raw sugar (brown sugar), 320 Kg of bagasse, 38.4 Kg of molasses and 40 Kg of filter cake is obtained (Anonymous, 2009). In many harvesting methods, controlled burning is used to remove dry leaves (straw and stubble of the sugarcane) or waxed cover of the stem. In some areas, harvesting is done manually by large number of labor force including local people and it has high costs for the producer. But today, because of its undeniable advantages, mechanized harvesting is selected as the main method in Iran and many other countries. Sugarcane harvesting may be done either in burnt or green method. In mechanized green harvesting method, top green leaves are removed and stems are collected and packed and transmitted to the mill, which this procedure may cause some problems for the sugar extraction systems (Ghari et al, 2009).

Post-harvesting waste

Post-harvesting waste is a concern in sugarcane industry. At the end of 19th century several reports were presented based on sugar waste (reducing of extracted sucrose). The first report was presented in 1907 by Brine and Belvin about the effect of invertase on post-harvesting waste and after that in 1913 the word “invert” was applied by Hall in the processing of sugarcane and subsequently other reports were presented in this field (Solomon, 2009).

Cruss and Blale (1915) confirmed the existence of invertase and reported that the maximum activity of this enzyme is in the storing procedure. Thus, through storing of some sugarcane juice with toluene and chloroform and analyzing them in a specific period of time, they found out that invert has extremely increased; so they proposed that sugar canes should be disinfected before the milling.

Alexander (1973) divided the post harvesting waste into two groups: 1) stale sugarcane and 2) fermented canes. In the first stage, sugarcane stems reduce the sucrose through breathing and inversion, and in the next stage microbiological waste is converted into organic acids -with the smell of rancidity- via lactic acid bacteria. The sensitivity of qualitative and quantitative factors against time delay

Sensitivity against time delay of harvesting to milling
Among the accomplished development projects of sugarcane in Iran, green harvesting showed the minimum decay and also green harvesting without chopper is superior to harvesting with chopper. The critical options for selecting the most appropriate method include corruptibility of green or burnt canes, the issue of purity decrease in non-burnt and non-harvested canes and finally the acceptable percentage of dextran in brix.

Corruptibility of burnt canes over time plays an important role in finding out the best time for burning the canes. Purity decrease in burnt and non-harvested canes is higher than harvested ones. The acceptance of canes in the factory is based on percentage of dextran available in brix and percentage of waste, and the more time delay is between harvesting and milling, the higher will be the amount of dextran in the extract.

The maximum time interval between harvesting and grinding of green and cleaned sugarcane should be 48 hours, this delay is 24 hours for burnt sugarcane and for chopper-harvested sugarcane it should not be more than 12 hours. Moreover, low temperature reduces quality loss of sugarcane (Facunni, 1993). In harvested sugarcane with chopper, dextran may reach to 5% of brix in less than 12 hours and about 30 hours after harvesting it may increase to 0.4% of brix (Shoshtari, 2007). Abdullahi (2002) reported that in green harvesting, which the stems of canes are completely harvested (without chopper), it is expected that the amount of sugar (sucrose) will be constant up to more than 4 days. On the other hand, choppered canes will decay rapidly so they should be milled within one day after harvesting. This issue may cause trouble for mills, where canes are gathered until weekend, thus the balance between input canes and capacity of the milling should be maintained. Hughes (1956) estimated the amount of sugar waste about 35% compared to fresh canes, after 4 days of warehousing. Burker et al (2004) reported 1.5% decrease of sugar (sucrose) per each day delay in milling. Chiranjeevi Rao (1989) notified 2% decrease of sugar refining as a result of more than 72 hours lag between harvest and milling. Solomon et al (2008) declared one unit decrease of pol for one day delay in milling and also estimated 5 to 10 Kg decrease of sugar per each ton of sugarcane which the amount is much higher in warmer months. Henderson and Kirby (1972) reported that increase in dextran, reduces the amount of commercial sugar in canes to a large content. Under normal conditions, time delay in sugarcane harvesting slightly reduces the amount of commercial sugar and mostly it is the increase of cane dextran - during harvesting to milling- which reduces the quality of produced sugar. Clark (1991) showed that for 0.1% produce of dextran, 0.04% of sucrose will decrease.

Saeed and Abdulkarim (1972) and also Legendre (1985) observed that if the chopped cane is not milled within several hours after harvesting, the available sucrose in cane scions will be inverted due to breathing process in the fractured parts of scions and also loss of injured cells sap and attacking of invertase microorganisms to scars; and as a result, cane quality and amount of recoverable sugar will decrease. Change of harvesting method from full stem into chopped stems will lead to cane corruption (Ridge, 1993). However Egan (1971) declared that chopped canes may be partly prevented from corruption, through reducing the interval between harvesting and milling. Cane corruption occurs as a result of transforming to
monosaccharide, generally glucose and fructose (Alexander, 1973). Kirby and Kingston (1978) stated that within 20 hours between harvesting and milling, damaged canes and canes shorter than 250 mm often decay very fast, compared to intact canes and canes longer than 250 mm. Foster (1977) and Yeno, Izomi and Sung (1986) reported that corruption of green canes scions is lower than burnt cane scions. Yeno and Izomi (1993) reported that the pace of corruption in damaged scions is lower in cold weather and increasing of temperature accelerates canes corruption, especially in extremely damaged scions within early 24 hours.

**Effective factors on post-harvesting sugarcane waste**

Solomon (2009) mentioned the effective factors on sugarcane staling as environment and growing area, pre-harvesting operations (such as belated fertilizing, burning and the intensity of fire, head cutting, etc), weather condition when at harvesting and storage time, harvesting method (manual and mechanized or burnet and green), storage method (pile, etc) and its duration, time delay between harvesting and milling, sanitary conditions inside and outside of the mill and also processing efficiency, loading method and the amount of mud with sugarcane, pests and diseases of sugarcane, effective factors on cane growing (product quality, salt, alkaline, dryness, water logging, glacial, high temperature, use of compost and vinasse). Main effective factors on sugarcane waste will be explained:

1) **Maturity of sugarcane**

The sugarcane variety has an important role in recovery of the sugarcane which weather and management plans affects it too and increasing the time delay between harvesting and milling will show off the role of variety. The maximum sugar which can be obtained is different in each variety. The precocious varieties increase their juice quality faster and they will have more sugar producing efficiency for harvesting at the beginning of the maturity season. Although, in terms of harvesting time delay, they will corrupt fast and the stems will sink in the mud and suberificate (Sabz ghabaee, 2002). On the other hand, the amount of fiber in sugarcane variety is directly related to increasing of waste (Larrahondo et al, 2002).

According to Guing and Baniabasbi (1978), maturity can be interrupted due to temperature decrease to freezing point and it cannot be compensated until the end of rainfall period. On the other hand, temperatures higher than 70° F have negative correlation with maturity (Sharifijoo, 2007). Mature sugarcane has less waste compared to premature and highly matured sugarcane, especially in tropical areas (Ahmad and Khan, 1988).

2) **Environmental factors**

Weather conditions extremely affect the amount of waste (especially when the temperature and humidity is high). According to Selmon et al (2000) 0.35 unit decrease of sucrose in winter, 1 unit decrease in spring and 1.32 unit decrease in summer per each day of milling delay was reported. according to Eggleston and Monge (2007) and legendre et al (2007), when the temperature reduces to lower than 22 ° F then all the top parts of commercial varieties will be destroyed and it will lead to significant effects on sugarcane extract in terms of sucrose, purity percentage, acidity, dextran amount and product yield. Humidity will produce more waste, especially when using mechanized harvesting, thus harvesting in rainy days should be avoided as much as possible. Raining by itself is not harmful but it pollutes sugarcane with mud and leads to transmission of polysaccharide-producing soil bacteria (Leuconostoc. Sp). This bacteria prefers environment with no air and when the air between canes reduces, due to mud pollution, its reproduction speed increase and this will reduce quality of sugarcane (Solomon, 2009).

3) **Mechanized harvesting**

Ahmad and Alemaddin (2014) found out that in mechanized harvesting of sugarcane the amount of brushwood is %10.04 (between 5.58% to 16.86%) and in manual harvesting it is %3.66 (between 8.5% to 2.76%), which the amount of delivered brushwood to the factory increases the costs of transportation and time duration of milling season. In mechanized and manual harvesting the weight of canes is respectively 10.07 and 6.10 tons on average in each trailer and there were 0.95 and 0.25 tons of subsidiary materials in each trailer, which have been stored in chopped, form thus the amount of waste increases. Solomon et al (2000) also reported that chopped stems of sugarcane significantly produce more waste than full-length ones.

4) **Green or burnt sugarcane harvesting**

In such two methods, each 1% increase of brushwood (other subsidiary materials) or each 1% increase of fiber in factory respectively lead to 0.1% and 0.9% decrease of sugar recovery, which is higher in burnt method (Ahmad and Alamadinn, 2014; Kent et al, 2009; Reed and Livent, 1989), and results in approximate reduction of sugar production. Despite the losses caused by brushwood in the factory, reduction of juice in burnt is lower than green method. Ino et al (1989) during a three-year experiment measured the amount of quantitative losses of harvesting respectively 3-17 tons per hectare (7.4 on average) and 3-7 tons per hectare (4.9 on average). The amount of quantitative waste in green harvesting was 1.5 times more than burnt harvesting (Ridge, 1993; ueno et al, 1989). Burnt harvesting has more waste than green harvesting, especially when milling is done by delay, such a way that the amount of sugar is 4% to 5% higher in green method (Sharifijoo, 2007). During four-year research in Texas, Wiedenfeld (2009) found out that the amount of sucrose in green harvesting was %6 less than burnt harvesting, in such a way that for first, second and third ratoon of green harvesting treatment the amount of sucrose was respectively 108, 126 and 124 Kg/Mg; while for burnt treatment was 112, 125, 115 Kg/Mg, the sugar product of second ratoon in green harvesting was less than burnt harvesting and had significant difference in %10 level of probability (9.4, 7.4 Mg/hectare). Comparative studies show that recovery is casually equal in these two methods, as a result of undesirable effects of burning (Sharifijoo, 2007; Norris, 2013; Gomez, et al, 20016). Studies and researches have been done in advanced countries in sugarcane industry. But unfortunately in Iran and especially in Khuzestan, despite the potential of this area, few studies have been done about the effect of harvesting delay and sensitivity of harvesting method, therefore the necessity of this study is quite clear.

**Materials and methods**

This research has been done in Hakim Farabi agro-industry of Ahvaz which is located in Khuzestan and is a public joint stock of Sugarcane Development Company in Iran.

**Waste, qualitative and quantitative factors caused by delay in milling**

In order to estimate waste and effective factors on sugarcane traits, caused by delay between harvesting to milling and extraction in the factory, a split-plot in time design was executed, with the randomized complete block basic design in 5 replications of 5 times with time interval about 24 hours was separately done on green and burnt sugarcane in a field (S4,24, CPea.1062 variety) and with the second ratoon which was appropriate for harvesting. Dimension of plots were 5x1.83 which 2 canes were harvested from each 1 meter of each plot.
Table 1. Analysis of variance related to method of harvesting and milling time delay on qualitative and quantitative traits of sugarcane

<table>
<thead>
<tr>
<th>Mean square</th>
<th>Juice percent</th>
<th>5 cane weight</th>
<th>Refined sugar</th>
<th>Yellow sugar</th>
<th>df</th>
<th>COV</th>
</tr>
</thead>
<tbody>
<tr>
<td>32.400**</td>
<td>0.070**</td>
<td>0.047**</td>
<td>0.068**</td>
<td>4</td>
<td>Replication</td>
<td></td>
</tr>
<tr>
<td>25.205**</td>
<td>0.002**</td>
<td>4.321</td>
<td>0.017</td>
<td>1</td>
<td>Harvest</td>
<td></td>
</tr>
<tr>
<td>16.065</td>
<td>0.246</td>
<td>0.012</td>
<td>0.017</td>
<td>4</td>
<td>Error</td>
<td></td>
</tr>
<tr>
<td>119.495**</td>
<td>2.267**</td>
<td>2.098**</td>
<td>3.046**</td>
<td>4</td>
<td>Time</td>
<td></td>
</tr>
<tr>
<td>65.120</td>
<td>0.047**</td>
<td>0.992</td>
<td>1.431</td>
<td>4</td>
<td>Time×Harvest</td>
<td></td>
</tr>
<tr>
<td>27.929</td>
<td>0.191</td>
<td>0.144</td>
<td>0.208</td>
<td>16</td>
<td>Error</td>
<td></td>
</tr>
<tr>
<td>15.701</td>
<td>23.572</td>
<td>4.309</td>
<td>4.302</td>
<td>(%)CV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1(continued): analysis of variance related to effect of harvesting time delay and method of harvesting on qualitative and quantitative traits of sugarcane

<table>
<thead>
<tr>
<th>Mean square</th>
<th>Quality ratio</th>
<th>Purity</th>
<th>Pol read</th>
<th>Corrected brix</th>
<th>df</th>
<th>COV</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.017**</td>
<td>0.869**</td>
<td>2.062**</td>
<td>0.182**</td>
<td>4</td>
<td>Replication</td>
<td></td>
</tr>
<tr>
<td>1.659</td>
<td>231.168</td>
<td>40.158</td>
<td>2.265</td>
<td>1</td>
<td>Harvest</td>
<td></td>
</tr>
<tr>
<td>0.005</td>
<td>0.710</td>
<td>1.720</td>
<td>0.044</td>
<td>4</td>
<td>Error</td>
<td></td>
</tr>
<tr>
<td>0.787**</td>
<td>58.832**</td>
<td>29.930</td>
<td>1.354</td>
<td>4</td>
<td>Time</td>
<td></td>
</tr>
<tr>
<td>0.376</td>
<td>28.958**</td>
<td>22.670</td>
<td>0.874</td>
<td>4</td>
<td>Time×Harvest</td>
<td></td>
</tr>
<tr>
<td>0.055</td>
<td>3.118</td>
<td>2.682</td>
<td>0.332</td>
<td>16</td>
<td>Error</td>
<td></td>
</tr>
<tr>
<td>4.333</td>
<td>1.465</td>
<td>3.595</td>
<td>3.208</td>
<td>(%)CV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Variance analysis of harvesting method and milling

<table>
<thead>
<tr>
<th>Mean square</th>
<th>Invert (%)</th>
<th>df</th>
<th>COV</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.085**</td>
<td>1</td>
<td>Harvest</td>
<td></td>
</tr>
<tr>
<td>0.029</td>
<td>1</td>
<td>Time</td>
<td></td>
</tr>
<tr>
<td>0.001**</td>
<td>4</td>
<td>Replication</td>
<td></td>
</tr>
<tr>
<td>0.003**</td>
<td>1</td>
<td>Time×Harvest</td>
<td></td>
</tr>
<tr>
<td>24.311</td>
<td>(%)CV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In fact, the number of 250 canes including 125 green and 125 burnt canes was harvested. In each plot, number of 10 canes was divided into 2 parts so that half part was burnt and other half was remained green in order to have a better judgment. To simulate the real conditions of sugarcane harvesting companies, harvested canes were divided into 25cm scions without any damage by using of especial scissor and then they were categorized into 25 group of green and 25 group of burnt sugarcane, and after tagging they were deposited in the open environment.

extract percentage = extract weight/cane weight×100 (1)

Then the juice was delivered to laboratory for analyzing and following tests were done. Figure 1 shows the especial three-roller mill used for extracting of sugarcane.

Brix which is in fact the percentage of solid materials solved in sugarcane juice, was measured using refractometer and through temperature correction table, the corrected brix was obtained.

Pol which is the measuring of sucrose concentration, was calculated using polarimetre. Then, the actual pol was calculate through pol factor tables (Equation 2).

Actual pol = read pol × pol factor (2)

Purity percentage is the weight ratio of sucrose to all the solved solid materials in the solution which is expressed in percent and is obtained through Equation 3.

Purity percentage = actual pol/corrected brix×100 (3)

Quality ratio is the estimated sugarcane tone required to produce 1 ton of commercial sugar obtained from analyzing of first millstone juice through purity factor tables, then the quality ratio is calculated using Equation 4.

quality ratio = purity percentage factor/actual pol (4)

If the purity percentage of a sample is less than 65, then purity percentage factor should be calculated using Equation 5 and 6, because it cannot be found in the table.

purity percentage factor = 79.3136x(j/j)[3.55] (5)

j = 1- purity percentage (6)

The yellow sugar obtained from 100 tons sugarcane is calculated through Equation 7.

yellow sugar = quality ratio /100 (7)

Figure 1. Three-roller mill especially designed for sugarcane extraction

Canes of each replication, which were packed, were weight by using a high accuracy scale. Then they were extracted in a milling factory simulator, known as especial three-roller mill. After extraction, the samples were weight using high accuracy scale and the percentage of extract was calculated by using Equation 1.
After refining procedures, the yellow sugar is transformed into white sugar. Due to years of experience and predictions about sugar production and the amount of refined sugar obtained from yellow sugar, the constant coefficient of 0.83 is used for calculation of recoverable white sugar through Equation 8 (Anonymous, 2007).

\[
\text{recoverable white sugar} = \text{yellow sugar obtained from 100 tons of sugarcane×0.83}
\]  

**Determining invert percentage of juice using Lane-Eynon method**

Sucrose hydrolysis leads to equal producing of glucose and fructose. The invert refers to its inversion of rotation direction compared to non-hydrolyzed sucrose. The amount of invert increases under inappropriate conditions such as microorganisms, improper pH, improper temperature (especially high temperature) and etc. In order to estimate invert sugar, Lane-Eynon method was applied.

**Results and discussion**

According to preformed experiments and calculation of burnt sugarcane sensitivity against time delay of harvesting, the analysis of variance related to time delay of harvesting was provided through Table 1.

According to Table 1 the interaction of harvesting method (burnt and green) and milling time delay had significant effect on sugarcane traits including read pol, purity percentage, quality ratio, yellow and white sugar. However this interaction had no effects on corrected brix, sugarcane weight and extract percentage; but milling time delay showed significant effect in 1% level of probability. Mean comparisons of the sugarcane traits which the treatments of method and time delay of harvesting had significant interaction, have been shown in Chart 1.

In compliance with the yellow sugar factor, the refined sugar in burnt harvesting was 12.29 tons per 100 tons of sugarcane in first day, and with each one day of delay it decreased so that in the last day (day 5) of delay it was 10.66 tons (1.63 tons reduction). Also in green harvesting, the amount was 12.60 tons for the second day (highest amount) and 11.52 tons for 5th day of delay (1.08 tons reduction). Therefore, green harvesting showed less sensitivity against time delay, compared to burnt harvesting. In terms of time delay, Solomon (1997, 1990 and 2000) and Sunita and Sharma (1994), reported 2% to 5% decrease of commercial sugar during 72 hours which confirms the results of this research. Also in issue of harvesting method, the results of this research matched the results of Eggleston (2001) and Barat Shushtari (2007) which reported 4% to 5% increase of sugar in green harvesting compared to burnt harvesting. But results did not match with Weidenfeld (2009) which reported 6% more decrease for green sugarcane compared to burnt sugarcane.

In some traits including corrected brix and cane weight, the interaction of harvesting method and time delay had no significant difference, but in treatments of harvesting method and time delay it was separately significant on corrected brix in 5% level of probability. Mean comparisons of harvesting method against corrected brix is shown in Chart 3.
According to Chart 3, it can be concluded that, burning of the sugarcane before harvesting in order to facilitate milling process, increases the amount of brix and has negative effect on the other qualitative and quantitative traits of sugarcane.

In addition to the harvesting method, sensitivity of brix against time delay is one of the determining factors on quality and purity of sugarcane. Mean comparisons of time delay effect on corrected brix is shown in Chart 4.

According to Chart 4, the amount of brix was 20.56 in first day and 21.35 in 5th day of delay which this difference was significant. The results matched with results of Barat Shusharti (2007) which reported 0.4% decrease of brix after 30 hours delay.

Interaction of harvesting method and time delay did not have significant effect on cane weight and only time delay affected cane weight. Chart 5 shows effects of time delay of milling on sugarcane weight.

According to Chart 5, by increasing in the time delay of the canes which have been divided into 30 cm scions, the weight decreased significantly from 3 Kg (average of 5 canes) in first day to 1.7 Kg (average of 5 canes) in 5th day of delay, and the reason was water loss of the plant. By the way, this point can directly affect brix traits of sugarcane.

Sugarcane invert which indicates corruption and quality loss of canes was calculated after intended experiments. Because of low temperature and experiments time period which was in winter, the invert pace has been low and has no significant difference until 72 hours. Therefore, time delay of 4 and 5 days was rendered (96 and 120 hours). Table 2 shows the analysis of variance for the interaction of harvesting method and time delay.

Results show that there is no interaction of harvesting method and time delay. But the harvesting and time treatments were separately significant in respectively 1% and 5% level of probability.

Burnt sugarcane invert was 1.7 times more than green sugarcane which was significant. It is notable that this amount is considerably higher in warm seasons (Chart 6).

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Conclusion

According to the results obtained from designs and experiments of this research, it can be said that the interaction of harvesting method and time delay of mill up to 5 days (120 hours) was significant on qualitative traits of sugarcane.
including pol, purity percentage, and quality ratio, yellow and white sugar in 5% level of probability. Decrease of purity percentage of burnt sugarcane was calculated to be twice as green sugarcane during 120 hours delay in milling. The amount of quality ratio increase in burnt sugarcane was 6.9 times more than green harvesting. The recoverable white sugar, which was affected by environmental conditions of harvesting method and time delay on sugarcane, was reported to be 0.7 time more in burnt sugarcane than green sugarcane. These results matched with most of the previous conducted studies.

Results obtained from analysis of variance showed significant difference on interaction of harvesting method and delay against amount of invert, due to low temperature in winter and also showed least effect on corruption of canes. But harvesting and time treatments were separately significant respectively in 1% and 5% levels of probability, in such a way that burnt sugar invert was 1.7 times more than green sugarcane and it was 1.35 times more in 5th day compared to previous day.

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References


