DIFFERENT ASPECTS IN SUGARCANE MATURITY CURVE AND HARVEST SCHEDULE – A Review

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Abstract *- Agriculture is the backbone of India. Almost all farmers facing problems of labour shortage. The demand for agricultural products and labour wages are increasing day by day in the todays increasing copetative world. sugar cane harvesting is labour –intensive activity in which workers become fatigued after manually cutting the cane for a long hours. They need frequent rest, experience sustained injuries from excessive stress on the joints and muscles of the body. Harvest scheduling practice is a direct impact on net farm returns. Sugarcane crops have distinct sucrose maturation curves, which vary up or down from year to year depending upon the climatic factors. A study was conducted on a commercial sugarcane farms to predict sugar per acre across the harvest season. Optimal adjustment of harvest of individual fields resulted in increased sugar yield per acre and total farm net returns.*

Key Words—*: Harvesting, scheduling, maturation curves, sugar yield and net ruturns*

1 Introduction

Sugarcane is basically a grows in hot climate. But it also grows well in subtropical climate. It grows well where temperature ranges between 20^0C to 40^0c. It responds well to long period of sunlight (12 to 14 hours), high humidity (above 70%) and high rainfall even upto 1500 mm. If settled irrigation water is available, it can also be grown in areas where rainfall is below 500 mm. As sugarcane crop remains in the field for more than 12 months, it withstands temperature variations of winter upto 6 to 8 deg.cent. and in summer 40 to 42^0C . Harvesting of sugarcane in India is carried out at 10 to 18 months stage, depending upon the planting time and crop maturity. In sub-tropics, autumn crop is harvested at 15 month stage, where as spring and summer (late-planted) crops at 10-12 months.

Harvesting of sugar cane is the most costlier operation in sugar cane farming. Many more practicle self-propelled sugar cane harvesters are in use in developed countries but manual harvesting is still adopted. Sugarcane harvesting operation may be done entirely manual, semi mechanization equipment or full mechanization equipments. Either harvested manually or mechanically, sugarcane may or may not burnet before harvesting. Variable sizes and designs of semi mechanization sugarcane harvesting machinery are available. Full mechanization systems may be whole stalk harvesting system or chopper harvesting system. many issues have been solved in some industries, the move to green cane harvesting and many of the associated economic agricultural practices remain a challenging prospect for many sugar industries.

Some Terminology Used In Sugarcane Harvesting As Follow:

Burnet Cane**:** Sugarcane is burnet to reduce the amount of trash in the cane before delivery to mill. The cane field or the cane heaps may be burnet before harvesting to facilitate getting-red of the trash and dry leaves.

Manual sugarcane harvesting: The manual sugarcane harvesting system consists of manually felling, topping, de-trashing, bundling and loading the canes into the transportation vehicles. Semi mechanization of sugarcane harvesting*:* semi-mechanized sugarcane harvesting system includes mix between mechanical and labor operations. Full mechanization of

sugarcane harvesting**:** The whole harvesting operation is done entirely mechanical and no labor are involved except for equipment operators. Whole stalk sugarcane harvesting: Sugarcane harvesting operation that harvest, handle and deliver the crop in the form of whole stalk regardless with the level of mechanization Full mechanization whole stalk sugarcane harvester: it is also named as Soldier- Cane-Harvester or (Louisiana type) which was mainly developed and used in Louisiana State in USA. Chopper harvester (sugarcane combine): A Single large machine performs all the functions of sugarcane harvesting. The machine harvest, chop clean and handle the cane in the form of billets.

Selecting a sugarcane harvesting machine will depend on too many factors, related to the particular sugarcane fields subjected to mechanical harvesting system as follow:

1- Harvesting time; (in wet weather - in dry weather)

2- Cane varieties; (structure and characteristics of cane crop plants).

3- Agricultural practices; (row spaces, irrigation system, furrow depth, field size, etc.)

4- Different machines to be used; (cane cutters, topper-cutters, soldier-cane harvester “Louisiana type”, chopper cane harvester or entirely manual)

5- Machine operation parameters.(several parameters)

6- Burning alternatives; (before harvesting- burning heaped- green cane harvesting).

7- Prevailing cane to mill delivery system.

8- Economics of mechanical harvesting.

2. Harvesting Procedure

The mature crop from the field. Harvester is a machine used for harvesting. Different types of harvesting machines are available in the market namely paddy harvester Tea harvester, Potato harvester

2.1 Manual Harvesting Hand knives, cutting blade or hand axes are used for manual harvesting. It requires skilled labourers as improper harvest of cane leads to loss of cane and sugar yield, poor juice quality and problems in milling due to extraneous matter.In Manual Harvesting to cut one acre of sugarcane 15-16 labours are required they take 3 days to cut one acre and involves harvesting of 60-70 tons per acre with labours being paid 500-550 Rupees per ton of harvest hence total cost of harvesting per acre comes up to 30,000-35,000 Rupees.

2.2 Mechanical Harvesting: Sugarcane is harvested by mechanical harvester which move along the rows of cane removing the leafy tops of the cane and cutting the stalk into short pieces or "billets". Billets are loaded into bins which are towed alongside the harvester. When full, the bins are taken by road or tramway to the sugar mill.The field capacity of mechanical cane harvesters varies with the size (2.5 to 4 ha per day of 8 hours)

2.3 Number of equipment/ machineries needed:

The total operational duration of the machine to complete an operationdepends on the capacity of the machine and number of available days to harvest. Number of working days for machines depends on the climatic conditions of that particular region. Wet soil and wet crops are the disincentive features to machine field operations. The available work days can be used to planning and scheduling of harvesting operations. Integrated Biomass Supply Analysis and Logistics (IBSAL) is a simulation model which relies on the crop characterstics to be criteria whether field work can be accomplished. But the simulatoin models requires the daily update for the weather impacts Simulation models needs daily updates of weather impacts and also the decision maker needs the reliable data to the weather related impacts

The selection of harvesting equipment depends on the number of available days to complete harvest. Higher capacity harvest equipment will complete field work more quickly then the low capacity ones. The high capacity equipments will have high depreciation, interest, and other ownership costs than the Lower capacity harvest equipment which will cost less to ownership, but may not complete the job, which may lead to non-compliance of a biomass feedstock contract. The size of machinery which complets the required work most efficiently will depends on the number of days it is going to be used for field work. For example, the round baler, being a smaller, lighter machine, will able to harvest more days than a large square baler because the profitable restriction is less.

The term “productive hours” is defined as the hours when biomass is actually operating in the field. Total operating hours include the hours spent servicing the equipment, operator breaks, and time required to move the equipment from the previous operating point (e.g., base of operations, previous field harvested) to the current field. Nighttime operation is not assumed to be practical for this analysis

It is understood that on some days the harvesting will be completed in the middle of the afternoon in one field and time is required to move equipment to the next field. Thus, the productive hours for that day are reduced. Also, there will be days when rain will shorten the number of productive hours. Some days, however, will have ideal conditions and the productive hours may be as high as 10 h.

3. Literature review:

Several studies have addressed various aspects of sugarcane productivity and harvest operations. Two studies were initiated towars the evaluation of economicics of sugarcane crop replacement evaluated the economics of sugarcan in Florida (Crane et al., 1982) and Louisiana (Salassi and Milligan, 1997). These studies evaluated the optimal crop cycle length by comparing annualized future net returns from replanting to estimated returns from extending the current crop cycle for another year. Semenzato (1995) developed a simulation algorithm for scheduling sugarcane harvest operations at the individual farm level in such a way that the lapse of time between the end of burning and processing is minimized. The model calculated the maximum size of a field which could be harvested and have all of its cane processed within a specified period of time. This study focused on farm size and equipment availability in order to efficiently utilize limited resources in a timely manner. Arecent study in Australia did determine optimal sugarcane harvest schedules which maximized net returns using mathematical programming procedures (Higgins et al., 1998; Muchow et al, 1998). However, the modeling framework in this study encompassed many farms within a production region over a multi-year harvest period.

4. Methodologies

The data were collected from five locations. Harvest data were collected from October to March during 4 consecutive seasons. Harvest samples were collected at approximately 2-week intervals, commencing on October 14 of each season and ending by March 27 of that particular year. Harvest dates within any given season represent the number of days after October 14. Maturity curves describing sugar per ton of sugarcane biomass (SPT, lbs sugar/ton) at 25 (early-season; Nov. 8), 75 (mid-season; Dec. 28), and 125 (late-season; Feb 16) days after onset of harvest were developed for each variety. Varieties were selected for this study based on either their recent release date. The first two digits in the variety name represent the year the variety was named, usually 7-10 years prior to variety release. Table 1 provides a brief description of the varieties included in this study. Varieties are ordered by release date in tables.

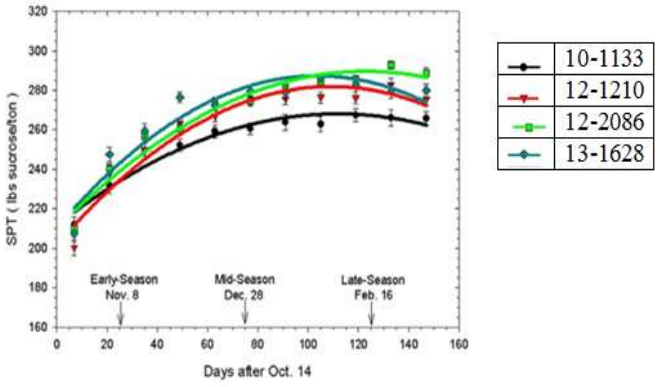

Figure 1. Sugar per ton (Y) versus harvest date (X) for CP clones 10- 1133, 12-1210, 12-2086, and 13-1628.

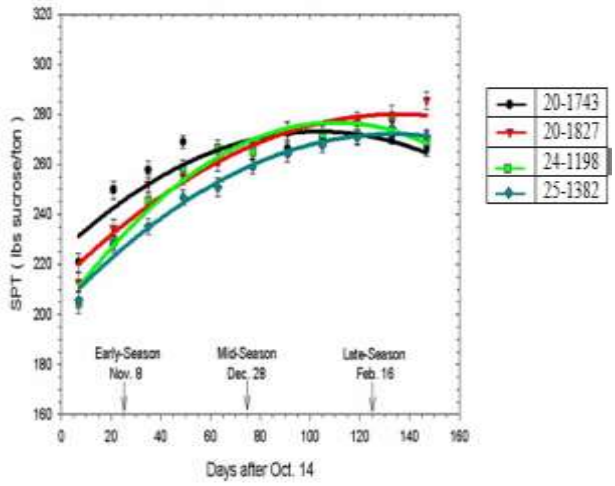

Figure 2. Sugar per ton (Y) versus harvest date (X) for CP clones 20- 1743, 20-1827, 24-1198, and 25-1382.

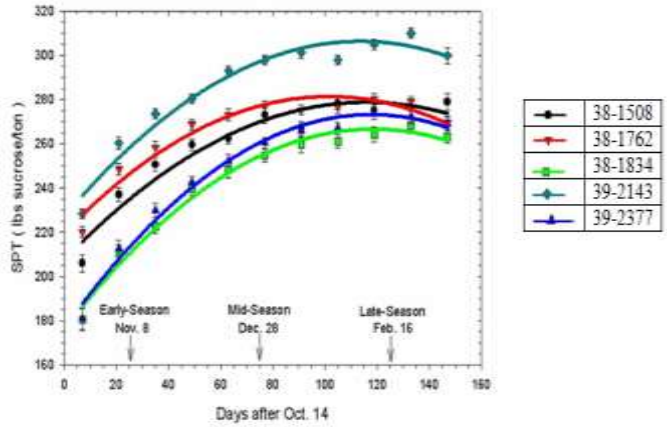

Figure 3. Sugar per ton (Y) versus harvest date (X) for CP clones 38- 1508, 38-1762, 38-1834, 39-2143, and 39-2377

Table 1. Sugarcane acreage and description of the CP varieties

CP Variety	**2001 acreage (% of total)**	**Photo/description**
10-1133	2.8	slowly being phased out of industry due to low sugar content and susceptibility to rust
12-1210	<1	Former widely-grown variety phased out due to susceptibility to rust, yellow leaf virus and ratoon stunting disease
12-2086	13.8	Slow early growth but good post-freeze characteristics
13-1628	11.5	Most widely-grown variety on mineral soils
20-1743	25.1	Vigorous tillering characteristics and well-adapted to mechanical harvest. Most widelygrown variety on muck soils
20-1827	5.1	Source of mechanically cut seed cane. Good post-freeze characteristics
24-1198	4.8	Large stalk weight, easily uprooted
25-1382	<1	Poor ratooning ability. Preferred host

38-1508	<1	Very erect variety, low sugar content.
38-1762	6.2	Large stalk weight, high plant population, subject to lodging
38-1834	<1	Susceptible to pineapple disease. Low sugar content.
39-2143	3.5	3.5
39-2377	<1	High tonnage but brittle stalks. Resistant to ratoon stunting disease
Total acreage	73%	(467,000 total acres)

5. Maturity Curves

SPT values at the onset of the harvest season (October 14) are presented in Table 2. CP 20-1743, CP 38-1762 and CP 39-2143 were notable for their high initial SPT values, which were significantly greater compared to 10, 8 and 11 varieties, respectively, indicating that they would be good choices for October harvest. In contrast, CP 38-1834 and CP 39-2377 had significantly lower initial SPT values than 11 of 12 varieties, and thus would be poor choices for early harvest. Maturity curves were also used to calculate optimal harvest dates based on maximum SPT for each variety (Table2). These dates ranged from January 26 (CP 20-1743 and CP 38-1762) to February 22 (CP 25-1382). Maximum SPT ranged from 267 lbs/ton (CP 38-1834) to 308 lbs/ton (CP 39-2143). Maximum SPT for 6 varieties at dates ranging from February 24 to May 17. The average maximum SPT for the 6 varieties in their study was 281 lbs/ton compared to 279 lbs/ton for the 13 varieties included in this study. It appears that maximum SPT for CP varieties has not changed greatly over the last 25 years, but the date of maximum SPT has shifted earlier in the harvest season. An exception to this is CP 39-2143, which has raised the standard for SPT levels significantly in recent years, causing lower SPT varieties to become less acceptable to growers

Maturity curves for varieties included in this study are presented in Figures 1-3. CP varieties named from 10-1133 to 13-1628 are included in Figure 1, varieties named from 20-1743 to 25-1382 in Figure 2 and varieties named from 38-1508 to 39-2377 in Figure 3. At the first sampling date, CP 10-1133 SPT was greater than or equal to that of CP 12-1210, CP 12-2086 and CP 13-1628, but there after SPT for CP 10-1133 increased at a notably slower rate over time (Figure 1). In contrast, the SPT of CP 12-2086 exceeded these varieties during the late-season harvest period. CP 12-2086, used as a standard in the CP breeding program, is known for slow early-season growth, but has maintained its acreage due to favorable late-season performance. CP 20-1743 recorded superior early-season SPT compared to other varieties named from 38 to 39 (Figure 3), but its relative SPT ranking decreased as the harvest season progressed. CP 39-2143 had clearly superior SPT compared to other varieties at all 11 sampling dates (Figure 3). CP 38-1834 and CP 39-2377 were notable for their poor SPT, particularly during the early-season.

6. Harvest Recommendations

While the calculation of maturity curves for individual varieties is informative, the relative ranking of a given variety in comparison to others is required to optimize harvest scheduling decisions. Table 2 presents SPT for each variety for early-season (25 days after Oct. 14), mid-season (75 days) and late-season (125 days) harvest dates, along with the variety ranking for each harvest period. The final column represents harvest schedule recommendations based on the change in variety ranking over time. For example, since the relative ranking of CP 10-1133 was highest early in the season (rank=8) compared to mid-season (rank=10) or late-season (rank=12), CP 10-1133 receives an early-season harvest recommendation. Other varieties that are recommended for early-season harvest based on these criteria are CP 20-1743 and CP 38-1762. Varieties that had their highest rank in mid-season included CP 13-1628 and CP 24-1198. Late-maturing varieties included CP 12-1210, CP 12-2086, CP 20-1827, CP 38-1508 and CP 39-2377. The ranks of CP 39-2143 (first) and CP 38-1834 (last) remained consistent throughout all harvest periods. CP 39-2143 should be planted by growers interested in increasing the sucrose content of their sugarcane crop, while CP 38-1834 is a poor choice for sugar production . While the consistently high rank of CP 39-2143

would suggest that it could be harvested throughout the season, compared to other commercial varieties indicate that it should be reserved for late harvest.

The most current grower cens indicates that the 3 varieties with the highest early SPT rankings, (CP 39-2143, CP 38-1762 and CP 20-1743), are also the varieties with the greatest expansion of plant cane acreage. In contrast, recently-released varieties with poor early-season 3 SPT (CP 38-1834 and CP 39-2377) have been planted on < 1% of the Florida sugarcane acreage. Varieties with < 1% acreage in the latest census (CP 12-1210, CP 25-1382, CP 38-1508, CP 38-1834 and CP 39-2377) had an average SPT of 188 lbs/ton in mid-October, while the remaining 8 varieties in this study (with higher adoption rates) averaged 210 lbs/ton. Growers are factoring SPT trends into their variety planting decisions. Maturity curve information contained in this fact sheet provides growers with a tool to make informed harvest scheduling decisions for these varieties.

Table2. Variety SPT (lbs sucrose/ton) and rank at 25 (Early Season; Nov. 8), 75 (Mid-Season; Dec. 28) and 125 (Late-Season; Feb. 16) days after onset of the harvest season, and harvest recommendation based on change in variety rank.

CP Variety	SPT	Rank#	SPT	Ranka	SPT	Ranka	Harvest Period Recommendation
	25 days (Nov. 8)		75 days (Dec. 28)		125 days (Feb. 16)		
10-1133	231	8	262	10	268	12	Early
12-1210	230	9	274	5	281	4	Late
12-2086	235	5	277	4	290	2	Late
13-1628	241	4	281	2	285	3	Middle
20-1743	242	3	270	6	272	10	Early
20-1827	233	6	267	9	279	5	Late
24-1198	229	10	268	8	275	8	Middle/Late
25-1382	224	11	258	12	271	11	Early/Late
38-1508	232	7	269	7	279	6	Late
38-1762	243	2	277	3	279	7	Early
38-1834	207	13	254	13	266	13	None recommended
39-2143	255	1	296	1	308	1	Early, Middle & Late
39-2377	210	12	259	11	273	9	Late*
Rank# : 1=highest, 13=lowest Late* : harvest preferred due to excellent post-freeze characteristics							

7. Conclusions

The historical and temporal variability underlying sucrose growth tendency was documented for CP sugarcane varieties. For the 8 CP ranges included in this study that are commercially growers are advised to harvest CP 10-1133, CP 20-1743 and CP 38-1762 in the early-season, CP 13-1628 and CP 24-1198 midseason and CP 12-2086 and CP 20-1827 in the late-season. CP 39-2143 has superior SPT throughout the 5-month harvest season, and should be planted in increasing sucrose combination of their sugarcane crop

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