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IMPROVED HARVESTING SYSTEM FOR SUGAR INDUSTRY IN INDIA

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ABSTRACT

Consistent supply of quality raw materials (sugarcane) for agro processing industries is lacking in many countries of the Region, with inefficient handling and transportation systems. The aim of this paper is to evaluate the current sugarcane manual and mechanical harvesting systems with regard to production efficiency and cost effectiveness in factory process. Different experiments were conducted to compare and contrast between the two harvesting systems. The results revealed that manual harvesting (98.47 Rs./ton) is more expensive than mechanical harvesting (54.28 Rs./ton). It could recommend that Bhima Sugar Factory as well as other sugar factories in Pune could go for increasing the mechanical harvesting. Sugarcane harvesting by a machine has a more capacity to cut the sugarcane faster compared to the manual one. Hence, need of using sugarcane harvester in India is necessary for faster rate of production of sugarcane products as well as harvesters take less time to cut the cane and cuts cane in smaller parts so that it becomes easy to transport with larger amount of quantity in one trolley.

Keywords: Manual Harvesting, Mechanical Harvesting, Sugarcane, Sugar Factory, Supply Chain Management.

I. INTRODUCTION

India is a country of villages and 75% population live in villages. Agriculture is main source of livelihood. However, sugarcane is cash crop and it generates more profit. India produces sugarcane on large scale. Tamil Nadu, Andhra Pradesh, Uttar Pradesh, Karnataka and Maharashtra are dominant states regarding production of sugarcane. In 38 districts of Maharashtra cultivate sugarcane as a main crop and Maharashtra having 250 sugar industries. Out of these Pune district has 40 sugar industries. So this paper focuses on improving productivity of sugar factory. From this research it is recommended some results to increase the production capacity of sugar factory, so that it will be definitely help in to increase the economy of state as well as country. [1]

The Supply Chain Management as a tool for improving the total quality management and production in process industries like Sugar industry. Sugar industry is a complex and repairable engineering unit, which comprises of various systems namely feeding, crushing, steam generation, crystallization and refining etc. Supply chain management is a central and important area of academic research due to its impact on process industries competing

in today's global economy. In today's competitive environment, it is extremely difficult to successfully produce high quality, low cost products without considering a satisfactory set of suppliers. Suppliers form the first link in the supply chain of any organization. Suppliers selection is a multi-criteria problem, which includes both qualitative and quantitative factors, Intelligent supply chain results in reduction of inventory, production and distribution costs, when production of sugar is high, consumption of sugar in domestic market is increasing, and their potential for industries are to perform well. Consistent supply of quality raw materials (sugarcane) for agro processing industries is lacking in many countries of the Region, with inefficient handling and transportation systems. The various problems and challenges of Indian sugar industry have been faced over years. This paper focused on inbound supply chain issues of Indian sugar industry. [2, 3]

II. LITERATURE REVIEW

It is well evident fact that SCM as an engineering tool improves the performance and is alike applicable in manufacturing areas but with varying performance. Therefore, a generalized performance assessment model is desired. The following literature is review to locate the existence problem and develop the frame work of the research.

Chellaswamy (2013) 34 companies were included for this study among 119 universal companies. The productivity ratios and the production function were computed by Solow model. Multiple Regression analysis was used to ascertain its impact on variables and they were tested by 5% level of significance. The analysis reveals that the relationship between Raw Materials and other independent variables i.e. the Capital, Labour and Sales has contributed 99 percent on dependent variable of the companies which started after green revolution period.[2]

The growth of the northern region has positive growth in terms of output, capital employed and also there is better rainfall and irrigation in this region than that of the southern region. The average growth of sugar industry was slower in the southern region than that of northern region due to poor irrigation and rainfall. There is a need for improving the productivity and it can be done by improving the quality of labour compensation.[2]

Mangal (2013) Supply Chain Management is a systematic approach to improve the total productivity of the sugar industries by optimizing the timing, location and quantity of material flow from sugar cane to sugar at consumer's site using IT infrastructure and interacting with all the related intermediates and that is expected approach for implementing TQM philosophy to improve organization. SCM and TQM are the ways to cost optimization one all along the chain while other related to total business, but both starting from customer order to the delivery of goods to him.[3]

Sethanan (2012) Thai sugar production has been confronted with various problems, especially the inbound logistics management system. From the field survey we conducted, we found that the logistics patterns of each growing region were different in terms of their production costs, harvesting and transportation time, and quality of sugarcane

supplied to the mill. Thai sugar industry has maintained its strength so far, but improvements are still necessary to meet new challenges. [4]

Deshmukh (2012) study has focused on the relationship between sugarcane growers and millers at a specific management level, the mill supply area. The relationship will be analyzed through the management of cane flows from the growers' fields to the mill as a way to enhance the mill area profitability. In the proposed Supply Chain Methodology an attempt will be made to minimize harvesting to crushing time to obtain the maximum possible sugar recovery to enhance the profitability of an organization. [5]

Pisal(2011) stated that industry faces the problem of excess sugar in the consecutive years when the sugarcane production is higher, the sugarcane harvesting needs to be well planned so the sugar mills can get the matured and fresh cane and the sugar growers can be benefited by timely harvesting of their sugarcane which will affect for better sugar cane yield, the losses occurred duly by non harvesting of sugarcane in proper time can have a big loss to sugarcane grower, as well as sugar mills because of unsecured environmental factors changing day by day which ultimately change the mindset of sugarcane grower and attract to different cash crops . The post harvest sugar lose is one of the most vexing problems of sugar industry and has attracted widespread attention in the recent years. [6]

III. NEW SUPPLY CHAIN MANAGEMENT SYSTEM TO OPTIMIZE HARVESTING

3.1 Problem Definition

The problem of labor shortage leads to introduction of mechanical cane harvesting to overcome the scarcity of labor. To overcome the problem of labor shortage Indian Sugar Company started to increase the mechanically harvested area. Hence the present paper aimed at analyzing sugarcane harvesting systems namely hand cut and vs. mechanical harvest (cut and load mechanically), with regard to productivity and cost effectiveness, in Bhima Sahakari Sakhar Karkhana (sugarcane factory), Patas.

3.2 Study Area

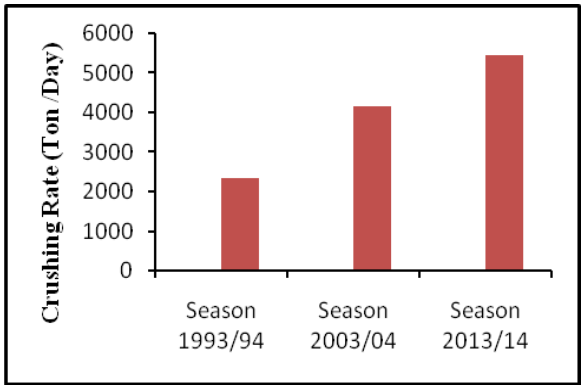
Patas is located in the hot semi-arid zone of central India, rains occur mainly in the period from June to October. The annual rainfall is between 450 and 500 mm the maximum temperature is high above 38^0C throughout the year, peak occurs in the period March through May with mean monthly maximum above 40^0C, mean monthly minimum during the cooler season from November to February is between 15 and 20^0C. The relative humidity at noon is low; the annual average is 29%. Irrigation water for Bhima Sugar Factory is provided from pump station which takes water from the Bhima River.

3.3 Bhima Sugar plant improvement

Table I indicates clearly the effect of the rehabilitation work and the renewal of the equipment carried out in Bhima Sugar Factory and till now the follow up is going on which leads to improvement year after year.

Table I Production data improvement in Bhima Sugar Factory due to rehabilitation.

Sr. No.		Season 1993/94	Season 2003/04	Season 2013/14
1	Season days	226	194	175
2	Area harvested	19421	23197	22448
3	Cane crushed (tons)	528766	802022	941282
4	Sugar Produced (tons)	41835	78188.5	92038
5	Average yield per acres	27.23	34.57	41.2
6	Average sugar tons per fed	2.15	3.37	4.03
7	Crushing rate tons / day	2339.4	4152.5	5438
8	Sugar recovery %	9.2	9.8	10.7
9	Sugar losses %	4.75	2.55	2.65



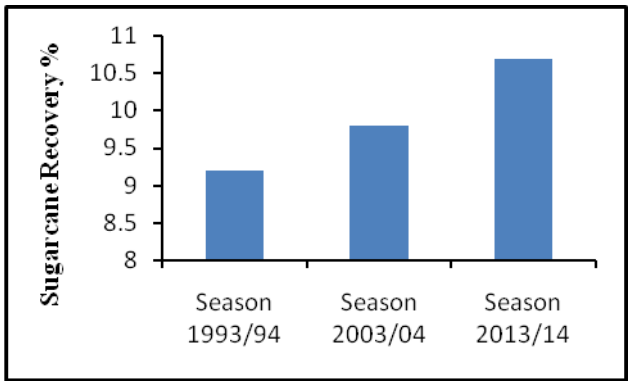


Fig.1 Crushing Rate (Ton /Day) for Bhima Sugar Plant Fig.2 Sugarcane Recovery (%) for Bhima Sugar Plant

3.4 Methodology

In the present paper both primary and secondary data were used. Primary data are obtained through personal communication, direct observation and discussion conducted formally and informally with the different departments in Bhima Sugar Factory. Moreover practical experiments had been carried out to compare the two harvesting systems.

3.5 Cane loading tonnage

Cane loading in Bhima Sugar Factory was mainly carried out by grab loader (whole stalk cane), and harvester (chopped cane). For both systems the cut cane loaded into trailers shunted by tractors is to be transported outside the field. To determine the average weight of cane loaded into trailer, a random sample of trailers has been taken for both systems (100 samples) and weighted empty and reweighed after loading.

3.6 Harvesting cost

The harvesting costs in Rupees/ton and Rupees/acres for both harvesting system were calculated.

IV. RESULTS AND DISCUSSION

4.1 Manual harvesting

Table II shows sugarcane manual harvesting productivity per unit land (Tons/Acre) and labor (ton/man/day). The tonnage harvested or cut per labor varies depending upon the tonnage of sugarcane in the field, as the tonnage of sugar cane in the field increase the tons of cane cut per man-day decrease. These results indicated that the cutting labor speed increases with the decrease of cane density and cane recumbence. The cane cutting labor output per day in this study was found with an average of 3.31 tons (Table II) compared with the previous five season 4.93, 4.89, 4.54, 4.92 and 4.69 ton/man/day for season 2009/2010, 2010/2011, 2011/2012, 2012/2013 and 2013/ 2014, respectively. It was clear that labor output/man-day was lower than that of the other five seasons (2009–2015). This is mainly due to increasing area under mechanical harvesting and restricted area with lower yield or crop density for manual cuts.

Table II Cane Cutting Labor Output

Month	Number of labor	Total output tons	Tons/man-day	Yield ton /fed
November	9620	42302.54	4.39	50.6
December	12868	56909.76	4.42	43.77
January	13318	42076.62	3.15	43.55
February	13977	38763.56	2.77	40.22
March	16585	45958.16	2.74	31.30
April	12485	35085.77	2.81	31.75
Total	78853	261096.41	-	-
Mean	-	-	3.31	39.29

The manually harvested cane will be mechanically loaded.

Table III Sugarcane loader productivity and performance

Loader No.	Output ton/ Season	Total working hours	Fuel consumption gallon/season	Ton/hr
1	6841.91	1205	682	10.0
2	33728.6	2646	4020	12.7
3	25817.9	2469	3125	10.4
4	16334.0	1129	1253	14.4
5	10046.1	1084	1388	9.62
6	33396.0	3046	3487	10.9
7	49424.7	3396	4051	14.5
8	35980.6	3140	2395	11.4
9	49526.3	3618	4767	13.6
Total	261096	21733	25168	
Avg.				12

Table III shows the performance of loaders in terms of total output, tons per hour, total fuel consumption during the season for each loader and fuel use expressed in terms of gal/h and gal/ton. The estimated performance rate was 30 ton/h as reported by Bhima workshop department while the average performance rate per hour in this study was found to be 12.01 ton/h. That means loaders performed only 40% from its estimated rate per hour, also loaders utilization percent throughout the season (173 day) was found 66.5%. This lower efficiency of all loaders was due to the fact that most loaders are at the end of their estimated life span (10 year).

4.2. Mechanical Harvesting Output

Table IV illustrates the total output of harvesters during the season 2014/2015, actual working days and hours and total fuel consumed.

Table IV Harvester group productivity and performance

Harvester No.	Output/ season ton	Actual working days	Actual working hrs	Ton/day
1	73375	159	2624	461.47
2	17171	62	752	267.94
3	9562	21	431	455.33
4	26717	57	956	468.71
5	90715	170	3244	533.61

6	93547	169	3345	553.53
7	83438	133	2984	627.35
8	109812	176	3927	623.93
Sub-Total	504337	947	18263	532.56
1	83698	136	2286	615.43
2	92149	136	2515	677.57
Sub-Total	175848	272	4801	646.50
Total	680185	1219	23064	557.98

Table IV shows the performance rate per unit time, ton/h. There are two types of harvesters working in Bhima Sugar, the two harvesters vary on their output and performance rate and so fuel consumption. The first type harvester represents the majority and its participation in total tonnage crushed was 74.2% while second type harvester was 25.8%. The average performance rate (ton/h) for both types was 27.61 ton/h for first type harvester and 36.62 ton/h for second type harvester.

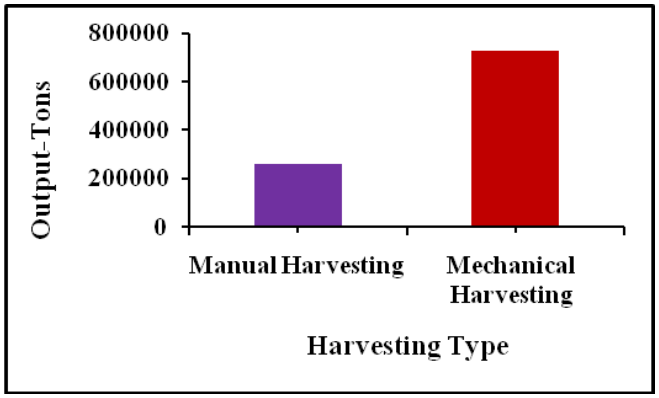


Fig.3 Comparison of Manual & Mechanical Harvesting in Tons

4.3 Cost determination

4.3.1 Manual harvesting cost

It composed of manual cutting and mechanical loading cost. The cost elements of the manual cane cutting include: labor collection and transport; cane cutting labor wages; cutting knife and file; accommodation; medicine and incentives. The average labor cost/man/day was found to be 197 Rupees of which 74% (146.57 Rupees) for cane cutting labor wage. When comparing the per day labor cost in present project with the last four seasons which is only 123 rupees/man/day for the season 2009/010 and peaked to 197.93 in 2014/15. This increasing trend in cost compels the Bhima Sugar Factory to go for mechanical harvesting against manual harvesting. As a result the percentage of the area harvested manually decreased from 93.88% in season 2009/2010 to 29.08% in season

2014/2015. Labor wages for sugarcane harvesting was 146.57 Rupees. The annual cutting labor earning covers only 49.8% of the standard living that is estimated by the World Bank. This implies that labor is under paid in sugarcane farm, keeping in mind that cutting sugar cane is a physical exhausting task that demands a high level of muscular strength and resistance. Accordingly labor prefers working in sesame and other crops as well as different jobs in town rather than cane cutting.

4.3.2 Mechanical loading cost per hour

Mechanical loading fixed cost /hour was found to be134.277 (30.7 % of the system cost/h), while the variable cost was 303.32 (69.3% of the system cost/h). The higher contribution of the total hourly cost was the repair and maintenance cost which represents about 32% of the total cost, and 46% of the total variable cost, this could be attributed to the use of 55% of total machine number behind their estimated life span. (10 year).

4.3.3 Manual harvesting cost per ton:

The results revealed that the total cane cut manually in season2014/2015 was 261096.41 ton and actual working days are173 days out of 176 days, with an average daily output of 1509.22 tons which contributes 23.2% of the total mill quota per day. The average cane cutter output per day was 3.31 ton. For mechanical loading the total working machine loader – was 9 units with total actual working hours of 21,733 h which represent 67% of the total available working hours (21 h/unit/day). The average output per unit per hour was found to be 12.01 ton. Manual cutting cost (Rupees)/ton cane was found to be 59.70 Rupees while the mechanical loading cost was only 37.38 Rupees.

4.3.4 Manual cost Vs mechanical harvesting cost

It was found that the actual daily crushing cane including factory stoppage (24 h) was found to be 5373.8 ton corresponding to 82.7% of the total design crushing capacity per day (6500 ton/day). The mechanical harvest was found to be 3864.7 ton/day representing the highest contribution percent in total crushing cane per day (71%) while manual harvest represents 29%. The results revealed that manual harvesting was more expensive than mechanical harvesting.

Table V Manual Vs Mechanical Harvesting Cost

	Unit	Variable Cost	Total Cost
Manual cane cutting	Rupees/ton	59.53	59.53
Cane Loading	Rupees/ton	25.25	37.28
Manual Harvesting Sub-total	Rupees/ton	87.07	98.47
Mechanical Harvesting	Rupees/ton	28.95	54.28

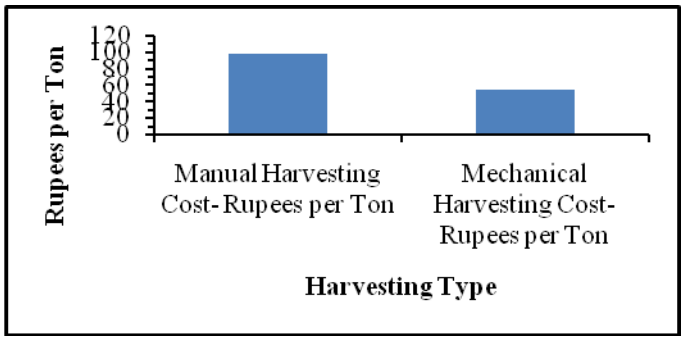


Fig.4 Comparison of Manual & Mechanical Harvesting Total Cost in Rupees

The variable cost contributed the highest percentage in both harvesting systems cost, where it contributes 88.4% and 53% of the total cost for the manual and mechanical harvesting systems respectively. The highest contribution of the variable costs in manual harvesting was mainly due to the highest contribution of the labor cutting cost, which represents 70.2% of total variable cost and 62.1% of total manual harvesting cost. It could be concluded that increasing mechanical harvesting area and reducing of manual harvesting area will result in decreasing the total cost of harvesting in Sugarcane factories in India.

V. CONCLUSION

Based on the above findings and discussion it is concluded that Bhima Sugar Factory as well as in other sugarcane factories in India could go for increasing sugarcane mechanical harvesting and reduce total harvesting cost to 44.19 rupees /ton of the total area. The specialized cane cutter labor should be employed in other agricultural operations during the offseason to insure their availability at the start of the season. A further research is needed to reduce the infield cane losses and trash percent and to determine their effect on cane quality and factory performance for the two harvesting systems.

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