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Status of farm Mechanization for *Saccharum officinarum* (sugarcane) in Narsinghpur, (M.P.), India

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Abstract
The aim of this study was to find out the farm mechanization status for *saccharum officinarum* (sugarcane) from the selected area of the study Narsinghpur, (M.P.) India.
Saccharum officinarum (sugarcane) was an important cash crop and it was cultivated between 32˚N to 32˚S latitude covering more than 90 countries of the world. India contributing 19.98% of the total world production was the second largest producer of sugarcane next to Brazil. *Saccharum officinarum* (sugarcane) was usually planted in the rainy period, between January and March, to be harvested in the following crop season, causing a productive system deficit of one year. *Saccharum officinarum* (sugarcane) was more labour intensive requiring about 3300 man-hrs per hectare for different operations. Considering the present trend of availability of labour for sugarcane production, it has been experienced that the use of modern machinery is inevitable.
The result was found after the study of selected area was better management of physical inputs, use of modern machineries for planting, intercultural operation and harvesting, timeliness of operations, saving in unnecessary tillage, quality seed, use of superior chemicals for plant protection, uniformity of water use resulted into a great positive effect which can be seen by output yield. The contribution of human and animal hours for bullocks farming of sugarcane was 3985 hr for man, 255 hr for bullock pair and for mechanized cultivation of sugarcane the contribution of human energy was recorded 3199 hr for the production of *saccharum officinarum* (sugarcane) in Narsinghpur.

Keywords: Mechanization, Sugarcane, Narsinghpur, Saccharum officinarum

Introduction
Mechanization as equipment that replaces or aids manual and animal work, it can be said that it is necessary in most phases of sugarcane production cycle to provide competitive and sustainable conditions for plant growth e.g. eradication of the stool, physical and chemical conditioning of the seedbed, soil moisture control, planting and agrochemical applications all the way up to cane harvesting and delivery [1]. Mechanization is particularly important in harvesting and transport operations from the field to the mill, as a consequence of the high amount of biomass that needs to be handled.
Technology and machinery enhanced the ability, quality, accuracy and efficiency of the human being. By using technology in any field the rate production and quality automatically increases [2]. The technological improvements in Indian agriculture since mid-sixties have brought about revolutionary increase in agricultural production [1, 2]. India's food grain productivity particularly in case of sugarcane, wheat and rice has also been increased with increase in the mechanization thus it is a good example for developing countries [3]. The country witnessed unprecedented growth in agriculture which has helped India to graduate from hunger to self-sufficiency in food grains by increasing the food grain production from 51 million tonnes to 208 million tonnes with surplus for export [1, 3]. The contribution of agricultural mechanization has been well recognized in enhancing the production together with irrigation, biological and chemical inputs of high yielding seed varieties, fertilizers, pesticides and mechanical energy. The farm mechanization is dependent mainly upon the size of land holding, sources and availability of farm power [4, 2, 1, 3]. Madhya Pradesh (M.P.) is the second largest Indian State in size with an area of 308,000 sq.km.

The population of Madhya Pradesh in 2001 was 6, 03, 48,000 comprising of 3, 14, 44,000 females [5]. The population density in the state was 196 per sq.km. Mean annual rainfall in the state varies from 1300 mm in Shahdol, Balaghat and Mandla in the east to 700 mm in Jhabua, Ratlam, Dhar, Barwani, Khargone and Khandwa in the west. In spite of high rainfall and presence of numerous rivers and rivulets, only 20% of the agricultural area is under irrigation. The state shows a spatial pattern in terms of dependence on various sources of irrigation [6]. While the rain rich eastern tract is more dependent on surface water for irrigation, groundwater dependence is found to be high in the western tract in general and Malwa Plateau in particular [7]. Agriculture is the mainstay of the State's economy and 74.73% of the population is dependent on agriculture. As much as 49% of the land area is cultivable. Around 20% of the total dry land districts of the country fall within Madhya Pradesh, reflecting the predominance of dry land agriculture in the state [8]. In recent years, there has been a gradual shift in the cropping pattern towards cash crop cultivation like cotton, soybean and sugarcane. Madhya Pradesh is endowed with rich and diverse forest resources. The forest area of the state is 95,221 km^2, consisting 31% of the geographical area of the state [9].

Scope of farm mechanization

The average power availability in M.P. state is about 0.69 kW/ha and target is to achieve 2 kW/ha by the year 2020 [10]. This is necessary to increase yield and cropping intensity also to enhance proper utilization of natural of natural resources. There is scope for utilizing high capacity machine for timeliness of operation, management of farm machinery vis-à-vis their utilization on small farms is quite low because of which farmers give comparatively low priority to purchase of agricultural machinery in comparison to other inputs viz., seed, fertilizers, chemical etc [11]. However, in present circumstances when labour wages are increasing at higher rate and their availability at peak time of sowing, harvesting is decreasing, the farmers are getting more inclined towards use of agricultural machinery [12].

The demands of good quality machines and better after sale and service facilities. Farm machinery industry will have to modernize their products not only in terms of performance but also for comfort, safety and energy conservation. In this agro-ecological zone farmers use mould board plough, disc harrow, cultivator and sugarcane planter on bullock and tractor owned farm [13]. The use of manual knapsack sprayer is also popular amongst the farmers. On tractor owned farms tractor drawn duck foot cultivator, rotovator, disc harrow and bund former are in use. The tractor operated sugarcane cutter cum planter, self-propelled sugarcane harvester and tractor drawn ratoon manager have tremendous scope in Narsinghpur Madhya Pradesh [14]. For tillage operation, rotovator is found to be cost effective in black cotton soil conditions of this region. The tractor operated sugarcane cutter cum planter and ratoon manager have good scope for adoption. The non-existence of standard production techniques and poor quality raw materials used in manufacturing of agricultural implements are the threats in this agro ecological region which gives extra burden to farmers [15]. The excessive use of chemical and fertilizers have resulted in lower land and crop productivity. The tractor and matching implement require proper training to avoid agricultural accidents during field operation. For sugarcane, manual sugarcane plantation and harvesting are prevailing in the region resulting into more human drudgery [16].

Sugarcane (*Saccharum Officinarum L.*) has been known from the earliest times even before the Christian era and ancient civilization. India is a home of thin class of canes. There are historical and botanical evidences to prove it. Sugarcane is a tropical and subtropical, perennial grass that forms lateral shoots at the base to produce multiple stems, typically 3 to 4 meters high and about 5 cm in diameter [17].

Sugarcane and sugarbeet are the two main sources of white crystal sugar. A general survey of sugar producing areas of world shows that about 80 countries crystallize sugar from sugarcane, while 35 from sugarbeet and 12 countries from both sugarcane and sugarbeet as well. 60 per cent of the total sugar in the world comes from sugarcane [18].

Sugarcane is the important cash crop of Narsinghpur and holds the prominent position as a cash crop. It is main source of sugar, gur and khandsari in the Narsinghpur [19]. It is cultivated in an area of about 2.3 thousand-ha with an average production of 75 tonnes/ha. Total production of sugarcane has been increasing steadily from 266.70 million tonnes in 2010-11 to 456.7 million tonnes in 2014-15. Sugar availability in the country has been about 185 lakh tonnes. To meet the requirement of increasing population, sugar production in the country has to be increased [20].

In Madhya Pradesh the area under sugarcane was 0.88 lakh ha, and production 4.22 million tonnes with productivity of 47.80 tonnes/ha and Narsinghpur district is one of the major sugarcane growing district in the state. The area under sugarcane was 23562 ha, with production of 125.2 thousand tonnes, which covers 18.3% area and 20.5% production in the states during the year 2013-2014 [19, 20].

Keeping in view the above, it was telling that, there is a need to study was to carried out to find the farm mechanization status for saccharum officinarum (sugarcane) from the selected area of the study Narsinghpur, (M.P.) India.

Material and methods

The experiment was carried out during cropping season of 2015-16 to study on status of farm mechanization for saccharum officinarum (sugarcane) in Narsinghpur, (M.P.) India. The material used and the method employed during the investigation are presented in this chapter under some following steps.

Design of research

Design of research is developed to enable the researchers to answer research questions as validly, objectively, accurately and as economically as possible. The research design used for this study was ex-post-facto, with the main objective of measuring the knowledge, attitude and usage of Agricultural implements and machinery by the respondents. Ex-post-facto research is a systematic enquiry in which the researcher does not have direct control on the independent variables because their manifestations have already occurred or because they are inherently not manipulability [21].

Location of the study area

Narsinghpur district is situated in the central part of Madhya Pradesh and Madhya Pradesh is located in the central part of India. Latitude 22º.45 north 23º.15 north, longitude 78º.38 east 79º.38 east, area 5125.55 sq. Km, 359.8 meters above

the sea. Narsinghpur district holds a special importance being located in the country. Which is a sacred as holy as river Ganga [22].

Selection of villages

Villages were selected on the basis of multistage stratified sampling method to represent the different agro-climatic area. of the state, in this study four villages were selected which covered wheat-rice, wheat-cotton and wheat-Jowar zone. While selecting village following parameters were also considered [11]:

- The population of the village should preferably be more than 1000.
- Land holding should be well distributed under different category.
- Urban effect should be minimum.
- Co-operation of the resident of village should be proper.
- The village should be well connected by road.

Selection of farmers

After selecting the villages for study, the farmers were randomly selected and contacted with the help of Gram-Pradhan. After collecting preliminary information related to their inventory, irrigation sources and type of farming system. It was tried that maximum farmers are contacted to have required information in present proforma [15].

Collection of data

The information including the quantity of energy inputs in the form of seed, fertilizers, chemicals, irrigation, human, animal, and prime movers. The output in the form of grain yield and by-product are to be determined from all the farmers of the villages falling in to different categories, further cropping pattern and hectare age under crop from farm to farm are also to be recorded. The operation time, fuel consumption, crop yield, and other parameters needed to be evaluated in a standardized manner. The data was collected with the help of pre-designed, pretested questionnaire. This information includes information regarding farmer's identifications, land holding, farm power and machinery availability, methods of irrigation, water availability. The utilization pattern of indirect source of energy viz. seed, fertilizer and chemicals. The proforma also included the details of power and machinery use for different field operations. The details of women/men and hired/owned labour were also received from the farmers [10, 13].

Availability of power

The inventory of hired (permanent and temporary) and family labour, draught animals (including all animals used for draught purpose carrying out agricultural operations), all power units including mobile (tractors) and stationary (diesel/gasoline engines and electric motors) were taken [11].

Availability of farm machinery

The inventory of the all the farm machinery in the farm of the hand tools, bullock operated implements, tractor operated implements, power operated implements, and rural transport devices/vehicles available with the different categories of farmers was taken [8].

Crop yield

The crop yield was also recorded by interviewing the farmers of the selected villages. Information like harvested crop and threshed crop in terms of weight was recorded in the pretested questionnaires [12].

9. Cropping intensity

It is calculated by dividing the sum of the cropping area in the kharif and rabi seasons by the net cultivated area. It is often represented in percentage [9].

10. Statistical Analysis

The energy data was analysed statistically. The mean and standard deviation of each of the parameter was calculated to test the significant difference in means. The't' test was applied to find the significance of difference between two means. The't' value was calculated by using the formula [11]:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\left(\frac{1}{n_1} + \frac{1}{n_2}\right) \times \left(SD_1^2 \times n_1 + SD_2^2 \times n_2\right)}{(n_1 + n_2 - 2)}} \quad \text{.....eq.1}$$

Where,

SD = Standard deviation = $(x_i - \bar{x})^2$
n_1 = Number of samples of mean x_1
n_2 = Numbers of samples of mean x_2

11. Arithmetic mean ($\bar{X}$)

The mean is the quotient that results when sum of all the items in the series is divided by the number of items [23].

$$\bar{X} = \frac{\sum x}{n} \quad \text{.....eq.2}$$

Where,

$\bar{X}$ = Mean
$\sum x$ = Sum of all the items
n = Number of items

Results and discussions

This section deals with the results obtained from the field studies and its interpretation of the *saccharum officinarum* (sugarcane) cultivation in the Narsinghpur district of Madhya Pradesh, India. This includes the demographic details. Under this study the following aspects were studied for the knowing of status of farm mechanization in the following selected crop such as, field preparation, sowing, interculture, irrigation, fertilizer application, FYM and chemical application, harvesting, transportation and then after ratoon management of *saccharum officinarum* (sugarcane) crop.

Field preparation

Field preparation is most important factor for the sugarcane crop for achieving high production of sugarcane in the selected area of study, Narsinghpur. Sugarcane crop requires well-prepared field for sowing. The many farmers are using the animal drawn plough, ridger and bund former for the field preparation. Field preparation through animal drawn implements takes more time and give very lower output. Field preparation with the help of animal takes more working time than tractor, preparation of field through animal takes 120 hr/ha shown in Table 1. But now the

tractors have replaced animal power to a great extent and are playing key role for farming operation not only in sugarcane but also in all other agricultural operations. The equipment like, disc plough, mould board plough, cultivator, duck foot cultivator, disc harrow, land leveller, rotovator, ridger, bund and channel former etc. are prevalently used in sugarcane cultivation. Field preparation through tractor takes less time than animal it takes 4 hr/ha for mould board plough, 3 hr/ha for rotovator and 4 hr/ha for cultivator, duck foot cultivator and disc harrow are shown in Table 2. Cultivator and disc harrow are shown in Table 2.

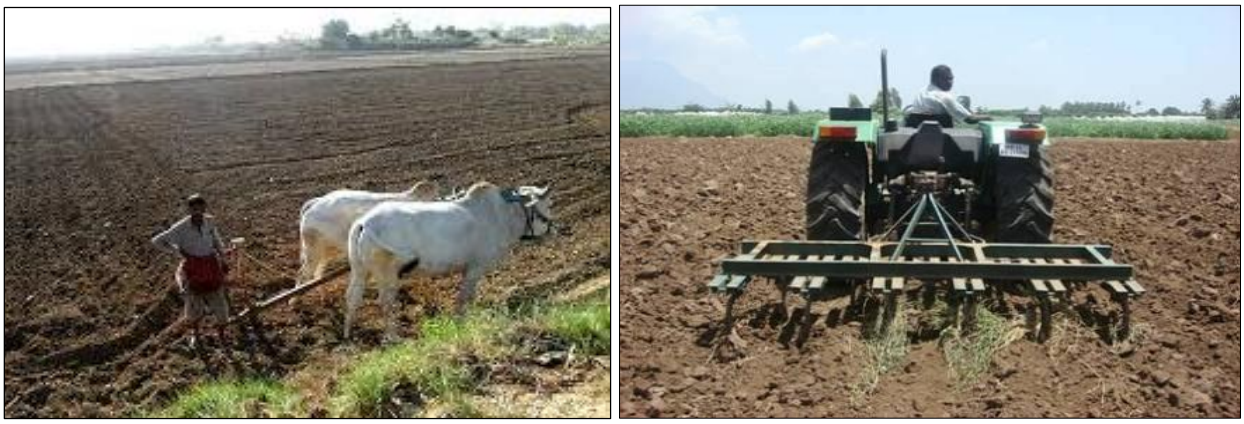

Plate 1: Field preparation for sugarcane crop by traditional and mechanized method.

For the field preparation of sugarcane, the farmers were applied two methods like traditional and mechanized method for field preparation which are shown in Plate-1. The mechanized methods are more energy efficient or time saving methods, so many farmers are adopting the mechanized method for this operation. The tractor or mechanized farming has replaced the traditional farming of sugarcane which was doing with the help of bullocks or animals in Narsinghpur.

2. Planting of sugarcane

In the selected area of study, Narsinghpur the sugarcane planting consumes about 25% of the energy required for sugarcane cultivation, and is the most labour intensive and laborious operation. About 250-man hr/ha shown in Table 1, are required for the whole operation including field operations, seed cane de-trashing, sett preparation, planting of sugarcane sets in the field and then after covering the sets into ridge from loose soil etc. the cutting of sets for sowing and manually planting of sugarcane sets into the field is shown in Plate 2 and Plate 3.

Plate 2: Sets cutting of sugarcane.

Plate 3: Manually planting of sugarcane.

Sets should be placed 10 to 15 cm deep into soil. Care should be taken to place eye buds on side and covered with thin layer of soil and then irrigation should be given to the field. In the area of sugarcane planting, sett preparation is done manually or mechanically, furrow opening is done by traditional country plough with fixing gunny bag filled with green tops or leaves on the wedge of the plough for widening the furrow.

The farmers have been following different planting methods viz., flat planting, trench planting, spaced transplanting and dual row planting, sugarcane cutter cum planter etc. The row to row space maintained by the farmers is mostly ranging from 75-125 cm but 90 cm is being the most common by the farmers in the Narsinghpur. The cost of sugarcane planting with mechanical planter may be reduced by about 60% and 85% labour as compared to the conventional system of cane planting. The average field capacity is about 0.2 ha/hr, the depth of placement of bud set is in the range of 160-180 mm and it takes 6 hours for completing 1 hectare sugarcane field shown in Table 2. The mechanical planting of sugarcane in the selected area of the study by the help of sugarcane cutter cum planter is shown in plate 4.

Plate 4: Sugarcane cutter cum planter for mechanized sowing of sugarcane.

3. Interculture in sugarcane

The sugarcane yield is heavily impacted by weeds in the field. As the sugarcane crop is grown under abundant water and nutrient supply conditions, possibility of weed growth is very high. These weeds also share the nutrients/fertilizers provided to the main crop, hence controlling these weeds are very important through interculture. The first hoeing and weeding should be carried 3-4 weeks after planting the cane. Farmers are used animal drawn cultivator shown in Plate 6, and it takes more time around 25 hr/ha for one time shown in Table 1. Mechanical cultivation or tillage is still the most important method for controlling weeds and is generally the most economical method where it can be used. The weeds may be uprooted, covered or cut off. In these days, the farmers have been used hoes, spades, khurpa, etc. shown in Plate 5, manual tools for uprooting the weeds but now a day many mechanical weeders like tractor and animal drawn cultivators, wheel hoe and power weeders are available.

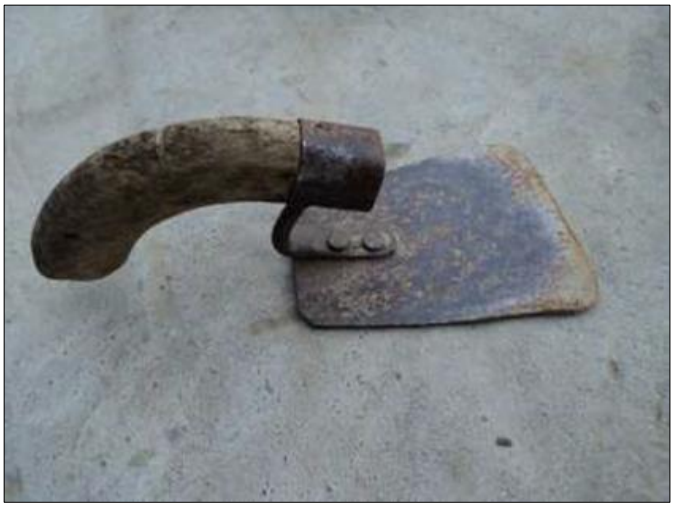

Plate 5: Manual interculture tool "Khurpa"

Plate 6: Interculture by bullocks

The mechanical intercultural operations required in sugarcane crop are weed control, moisture conservation and creation of better environment for overall growth of plant. After emergence, weeding is done with the help of tractor drawn or animal drawn cultivators. Tractor drawn cultivators and duck foot cultivator can effectively be used by adjusting the spacing between the tines as per the row to row spacing of the crop shown in Plate 7. The duck foot cultivator is more adopting interculture implement by many farmers from the area of study, it is more time saving implement and it can easily operate between two rows of sugarcane by the help of 30 to 45 hp tractors because of its adjusting tines. It provides shallow ploughing between rows and destroy all kinds of weeds from field and it takes 3-hour time for done interculture operation for 1-hectare field of sugarcane in the selected area of study Narsinghpur shown in Table 2. The duck foot cultivator is shown in Plate 8.

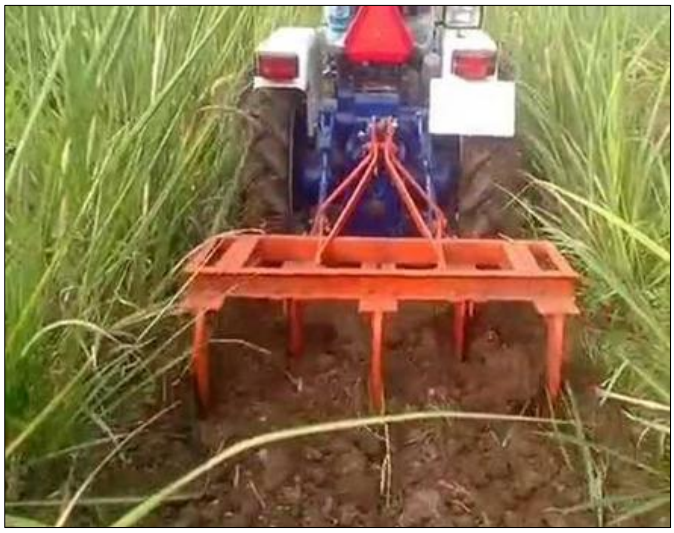

Plate 7: Intercultural by cultivator.

Plate 8: Duck foot cultivator.

4. Harvesting of sugarcane

Harvesting is the most important operation for sugarcane crop after maturing the crop for getting the profit of crop in the form of cash. The farmers were used to cut the sugarcane crop by traditional method like; manually by using special cutting tools like; various types of knives, sickles and other tools. The harvesting is more labour required operation in the selected area of study, Narsinghpur. The farmers cut the cane from the bottom and put them in a sequence manner and then after de-trash the leafs from cane and separate cane from leaf. Under the present time due to non-availability of labour, the harvesting gets delayed affecting the production of sugar. This operation is required 1250 man hours for harvesting 1 hectare of sugarcane shown in Table 1. The manually harvesting of sugarcane is shown in Plate 9.

The mechanization efforts in the area of study have been basically limited to the adoption of whole stalk harvesters for the partial mechanization of harvesting of sugarcane. The mechanical means for harvesting of sugarcane crop so as to improve the quality of cutting and reduced energy input. In the selected area of study peoples are adopting the sugarcane harvester for harvesting the sugarcane and also for all the operations like cutting, conveying, billeting can be done within the machine which is hired by farmers. They also used different tools and machines for harvesting of sugarcane crop in Narsinghpur. The farmers have done harvesting process of sugarcane in 12 working hours for 1 hectare by using the sugarcane harvester shown in Table 2. the sugarcane harvester is shown in Plate 10.

Plate 9: Manually harvesting.

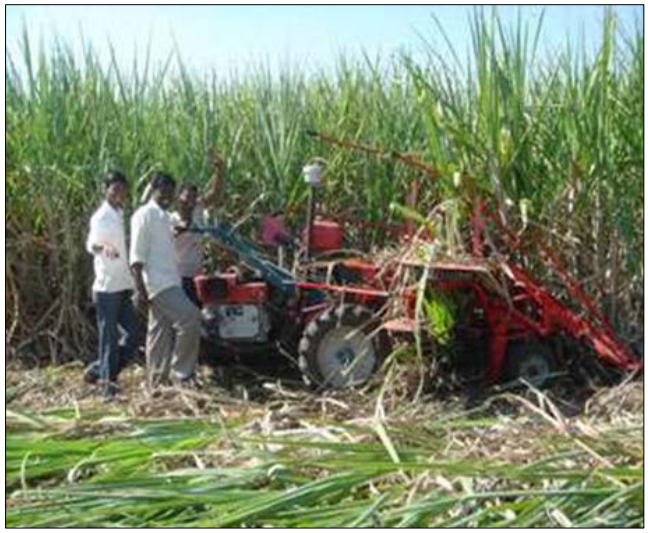

Plate 10: Sugarcane harvester.

5. Ratoon Management

In the selected area of study, the ratooning is a method where the lower parts of the plants along with the roots are left uncut at the time of harvesting gives sprouting of ratoon. In ratoon crops, there is a saving in cost of cultivation in terms of land preparation, seed canes, etc. If ratoons are well maintained, they give high yields. But, for a better ratoon crop, a better plant crop is necessary. Within a week after harvesting the plant crop, ratoon management practices like stubble shaving, off baring, gap filling, fertigation etc., should be initiated. The required time of mechanized ratoon management through ratoon management device is 8 hr/ha shown in Table 2. In the traditional way the farmers were spread the trash/leaf over the hole field where the sugarcane has harvested and then de-trash the leaf by using bullock drawn harrow and merge them into the soil. Some farmers were burned the leaf which are spread over the harvested land of sugarcane and then irrigate the field and this operation can take 35-man hr/ha, shown in Table 1. The ratoon manager device is shown in Plate 11.

Plate 11: Ratoon manager device.

6. Transportation

The harvested cane is transported to sugar mills for its processing using different modes of transportation viz. Bullocks carts, tractor operated trailers and trucks. The commercial loading and transport vehicles could be

effectively used for moving the canes from the field to sugar mills for crushing and further processing. In the past time peoples were transport the harvested sugarcane by using bullocks cart from field to the mills and it takes 12-80 hours, shown in Table 1, and now it's a time of mechanized farming then the peoples are adopting tractors and trucks for the transportation of sugarcane from field to sugar mills and it takes 5-25 hours, shown in Table 2. In the operation of transportation, it can-not be clearly defined the actual working hours of bullock carts or tractors/trucks because of it is totally depend upon the distance between field to sugar mill. The process of transportation by using bullock carts and tractors are shown in Plates 12 and 13.

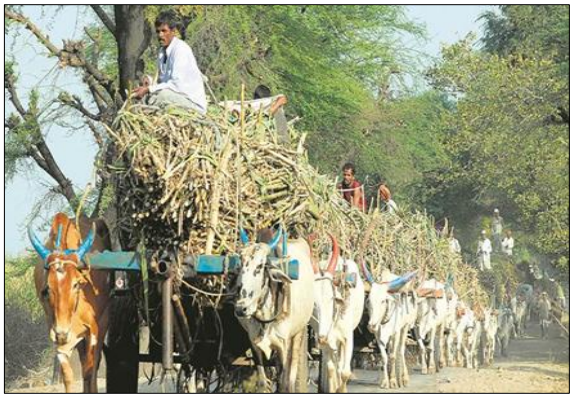

Plate 12: Transportation by bullocks

Plate 13: Transportation by tractors

Table 1: Traditional farming of sugarcane in Narsinghpur, Madhya Pradesh

Items	Use of hours/hectare for traditionally farming of sugarcane					
Field operations	**Bullock pair (hr/ha)**	**Human (hr/ha)**	**Tractor (hr/ha)**	**Machinery (hr/ha)**	**Electric motor (hr/ha)**	**Remark**
Field preparation	120	120	-	120	-	B.D. M.B. plough x 1, B.D. Cultivator x 1, B.D. Patela x 1 and B.D. Bund former x 1.
Sowing/Planting	-	250	-	-	-	Manually
Interculture	75	150	-	75	-	B.D. Cultivator x 3
Irrigation	-	1625	-	-	1625	7.5 hp
Chemical application	-	48	-	24	-	Manual sprayer
Fertilizer application	-	120	-	-	-	Manually x 3
FYM application	-	200	6	6	-	Manually and Tractor trolley
Harvesting	-	1250	-	-	-	Manually
Ratoon management	-	42	-	-	-	Manually
Transportation	60	180	-	60	-	Bullock cart and Tractor trolley
Total	255	3985	6	285	1625	
Yield q/ha	1st Year Production = 525 q/ha, After ratooning 2nd year = 700 q/ha and 3rd year = 500 q/ha.					

Source; Avinash Kumar. 2017. Energetics of sugarcane in the District of Narsinghpur, Madhya Pradesh. Unpublished thesis, COAE, JNKVV, Jabalpur.

B.D. = Bullock drawn, M.B. = Mould board, FYM = Farm yard manure, hp = Horse power, q = Quintal, hr = Hours and ha = Hectare.

Table 2: Mechanized farming of sugarcane in Narsinghpur, Madhya Pradesh

Items	Use of hours/hectare for mechanized farming of sugarcane					
Field operations	**Tractor (hr/ha)**	**Human (hr/ha)**	**Bullock pair (hr/ha)**	**Machinery (hr/ha)**	**Electric motor (hr/ha)**	**Remark**
Field preparation	11	22	-	11	-	T.D. M.B. plough x 1, T.D. Cultivator x 1 and T.D. Bund former/ridger x 1.
Sowing/Planting	6	60	-	6	-	Sugarcane cutter cum planter
Interculture	2.5	5	-	2.5	-	T.D. Cultivator x 3

Irrigation	-	1625	-	-	1625	7.5-10 hp
Chemical application	-	48	-	24	-	Manual sprayer
Fertilizer application	-	120	-	-	-	Manually
FYM application	6	200	-	6	-	Tractor trolley
Harvesting	-	720	-	12	-	Sugarcane harvester
Ratoon management	8	24	-	8	-	Ratoon manager device
Transportation	25	375	-	25	-	Tractor trolley
Total	58.5	3199	-	94.5	1625	
Yield q/ha	1st Year Production = 875 q/ha, After ratooning 2nd year = 1375 q/ha and 3rd year = 1120 q/ha.					

Source; Avinash Kumar. 2017. Energetics of sugarcane in the District of Narsinghpur, Madhya Pradesh. Unpublished thesis, COAE, JNKVV, Jabalpur.

T.D. = Tractor drawn, M.B. = Mould board, FYM = Farm yard manure, hp = Horse power, q = Quintal, hr = Hours and ha = Hectare.

Conclusion

The overall result shows in the selected area of study is the importance of the role of farm machineries in the production of sugarcane. Although the level of mechanization in this region was higher than the traditional level of mechanization. The requirement of mechanization was needed many places in the study of area, Narsinghpur for cultivation of sugarcane are planting, harvesting and de-trashing because these are the high labour consuming operations. There is no any doubt that the sugarcane harvester and sugarcane planter machines are more labour saving, cost saving, reduce human drudgery and make sugarcane cultivation more profitable than compared to traditional cultivation of sugarcane in the selected area of study Narsinghpur, (Madhya Pradesh) India.

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