

Demand of energy for mechanization in sugarcane cultivation in Narsinghpur, (M.P.), India.

ABSTRACT

The purpose of this study was to determine the demand of the energy for mechanization in sugarcane which was involved in cultivation of sugarcane from primary tillage to ratoon management of the crop during 2013-14 in the selected area of study, Narsinghpur (M.P.), India. Agricultural mechanization implies the use of various power sources and improved farm tools and equipment, with a view to reduce the drudgery of the human beings and draught animals, enhance the cropping intensity of sugarcane. The demand energy for production of sugarcane is highest as compared to many other crops such as potato, maize, wheat, paddy, sorghum etc. Sugarcane is 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. However, the adoption of these implements and machinery have not been up to the desired level. Thus there is a considerable mechanization gap, especially in the area of sugarcane planting, interculture, plant protection, harvesting and ratoon management. This study deals with the whole process of developing mechanization and describes the demand of energy for mechanization of sugarcane in Narsinghpur, (M.P.) India.

Keywords: *Mechanization, Sugarcane, Narsinghpur, Cultivation of sugarcane, Demand of energy.*

INTRODUCTION

Energy is the key of Life. Energy comes from food and thus from agriculture. Agriculture depends on energy input. Energy capacity of activity. Survival, convenience and comfort of human being depend on how best the energy is captured transformed and utilized. To identify the energetic relationships of agricultural systems and to be understood. We must be able to correctly identify and measure the flow of energy in the system. We call such activities as agricultural

energetics [1].

Mechanization in cultivation of sugarcane 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. physical and chemical conditioning of the seedbed, soil moisture control, planting and agrochemical applications all the way up to cane harvesting and delivery. 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 [2,1].

Technology and machinery enhanced the ability, quality, accuracy and efficiency of the human being. By using technology in sugarcane field the rate of production and quality of sugarcane automatically increases. 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 [3].

The availability of power on the farms in India has to be increased, if productivity is to be raised. More power is needed for timely and quality tillage, as well as for irrigation and harvesting. Quantification of energy panorama, involve scientific surveys of various input energy forms, and this may be termed as 'Energy Audit' [2]. Power energy audit would provide better understanding of changes in energy consumption patterns and would become a measure of technological progress in energy utilization efficiency [1]. It will also provide better guidelines for inter and intra system allocation of energy resources. The projects which constitutes the subject matter of this thesis, and the results of which are given at the end, were taken up, with a view to collect and collate all available information about energy consumption in Madhya Pradesh agriculture, and suggest tentative guidelines for future workers, on energy scene in this State [2,4].

Agriculture is one of the most significant sector of the Indian Economy. Agriculture is the only means of living for almost two thirds of the workers in India. The agriculture sector of India has occupied 43% of India's geographical area, and is contributing 16.1% of India's GDP. Agriculture still contributes significantly to India's GDP despite decline of its share in India's GDP. There are number of crops grown

68 by farmers. These include different food crops, commercial crops, oil seeds etc.,
69 sugarcane is one of the important commercial crops grown in India [5].

70 **Sugarcane** is usually planted in the rainy period, between January and
71 March, to be harvested in the following crop season, causing a productive system
72 deficit of one year. During the period between the harvest of the last cycle and the
73 planting of the new one, some mills do crop rotation with legume species [3]. Cane
74 harvesting use to be traditionally done manually, but it has witnessed a rapid
75 transformation in the last decade due to mechanical harvesting, mainly as a
76 response to environmental legislation that restricts the use of field burning. Major
77 sources of farm power include both animate (humans and draught animals) as well
78 as inanimate sources such as diesel engines, tractors and electric motors [3,6].

79 **Sugarcane** is a most important cash crop of India. It involves less risk and
80 farmers are assured up to some extent about return even in adverse condition. In
81 agriculture sector, sugarcane shared 7% of the total value of agriculture output and
82 occupied 2.6% of India's gross cropped area during 2006-07. Sugarcane provides
83 raw material for the second largest agro-based industry after textile. About 527
84 working sugar factories were located in the country during 2010-11 with total
85 crushing capacity of about 242 lakh tonnes [7].

86 The energy requirements in various facets of agriculture (including livestock
87 production and household's activities) vary considerable due to variations in the
88 technology level adopted by the farmers and also because of the diverse agro-
89 climatic conditions. Technology level and agro-climatic conditions constitute the most
90 important factors pertinent in the production of a crop in the state of Madhya
91 Pradesh. Agriculture is the main source of income of the majority of the population of
92 the state [2,4].

93 **Narsinghpur** district is situated in the central part of Madhya Pradesh &
94 Madhya Pradesh is located in the Central part of India. Latitude 22°.45 North 23°.15
95 North, longitude 78°.38 East 79°.38 East, Area 5125.55 sq. Km, 359.8 meters above
96 the sea. Narsinghpur is a district, which is well known for its fertile land, it is said to
97 be the most fertile land all over Asia. Black soil suited for any kind of cultivation
98 blessed with adequate irrigation facilities. District is famous for its rich agricultural
99 production. Being situated at upper part of Narmada Valley, which is much important
100 for agriculture [8]. District's production of grains is more than the actual requirement.

For agriculture both old and new techniques are equally in practice. In old equipment there are Ploughs, Bullock Carts, Bakhar, Hansiya Various types of knives and khurpi etc. In new methods or techniques Thrashers, Tractors, Harvesters, electric pumps, sprinklers etc. Along with these better quality seeds and best quality pesticides are used. The area covered for sugarcane production is 24 thousand hectare and corresponding yield was 4386 Kg/ha during the year 2009-10 [9].

Sugarcane is an energy and irrigation intensive crop. In the selected area of study Narsinghpur, (M.P.) the sugarcane cultivation is generally based on traditional methods which are labour intensive and involve heavy physical work. A number of labour saving machines and tools have been developed for various farm operations [8].

MATERIAL AND METHODS

3.1. 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 sugarcane-rice, sugarcane-cotton and sugarcane-wheat zone. While selecting village following parameters were also considered:

- ✓ 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.

Data were collected on the pre-tested proforma by combination of interview method and by taking actual measurement if required. The physical data were converted on common denominator by multiplying them with the appropriate energy equivalent coefficient.

3.2. 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.

3.3. 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.

3.4. 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.

3.5. Specific energy

Energy requirement for per kilogram production of grain is known as productivity. It is defined as the total energy required to produce a unit weight of main product. It is calculated by dividing the total input energy by the yield of the main product and represented as MJ/kg.

3.6. Energy calculation for field operations

The energy used in the particular field operation was calculated as sum of human, animal, mechanical and electrical energy consumed. Energy consumption from both in terms of renewable and non-renewable energy and commercial and non-commercial energy sources (direct & indirect) was also quantified for different crops and cropping pattern.

3.7. Relationship Between productivity and total energy inputs

Relationship between total energy, MJ/ha (E_i) and total productivity, kg/ha (P_i) of the i^{th} farmer was established using function

$$P_i = f(E_i, A_i) \dots\dots\dots \text{eq. 3.1}$$

E_i = Total energy inputs (MJ/ha) of i^{th} farmer

The statistical models used to establish the mathematical relations have been given in table 1. The best-fit relation was selected based on:

- ✓ Value and significance of coefficient of multiple determination, R^2
- ✓ Logicality of sign and significance of coefficient of elasticity.
- ✓ Statistical closeness of observed and predicted production by plotting graph between the observed v/s predicted production.

Table 1. Mathematical relations used for best-fit relations.

S. No.	Function's	Mathematical relationship
1.	Linear	$P = b_0 + b_1E + b_2A$
2.	Quadratic – linear (Energy - Area)	$P = b_0 + b_1E + b_2A + b_3E^2$
3.	Quadratic – quadratic (Energy - Area)	$P = b_0 + b_1E + b_2A + b_3E^2 + b_4A^2$
4.	Semi-log	$P = b_0 + b_1\ln(E) + b_2\ln(A)$
5.	Cobb-Douglas (Double-log)	$\ln(P) = b_0 + b_1\ln(E) + b_2\ln(A)$

The relation between yield, kg/ha (Y_i) and energy input, MJ/ha (X_i) was derived by dividing both sides by area (A_i) as under.

$$P_i/A_i = 1/A_i \{ f(E_i) \} \dots\dots\dots \text{eq. 3.2}$$

In case of Cobb-Douglas relation it will yield as:

$$Y_i = f(X_i, A_i) \quad \text{if } \sum \beta_p \neq 1$$

$$Y_i = f(X_i) \quad \text{if } \sum \beta_p = 1$$

$$(\sum \beta_p = \text{sum of regression coefficients})$$

RESULT AND DISCUSSIONS

This section deals with the results obtained from the field studies and its interpretation of the sugarcane cultivation in the Narsinghpur (M.P.) India. This includes the demographic details. Under this study the following aspects were studied such as, energy use pattern through direct and indirect sources, farm machinery and power availability in Narsinghpur (M.P.), effect of operation wise energy requirement and optimization of energy use and prediction of energy requirement from different sources for mechanization in sugarcane and required yield level of sugarcane for selected area, Narsinghpur (M.P.).

In India, the total area under sugarcane cultivation was reported to be about 49.18 lakh hectare. The country produced about 3414.25 lakh tonnes of cane at a national average of about 69.42 tonnes/ha in the year of 2013-14. India occupies the second rank in production of sugarcane in the world and contributes nearly 20.4 % area and 18.60 % production. The major sugarcane growing states are Uttar Pradesh, Maharashtra, Tamil Nadu, Karnataka and Madhya Pradesh etc. The area and production of sugarcane in Madhya Pradesh is about 0.73 lakh hectare and 31.73 lakh tonnes. The production, yield and area of sugarcane in Madhya Pradesh is given as following fig. 1.

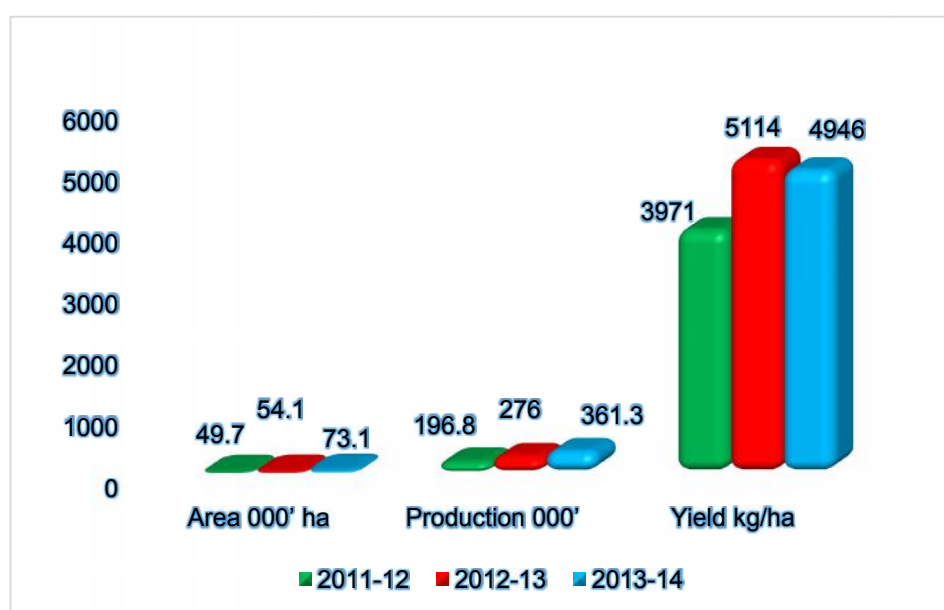


Fig. 1. Production, yield and area of Sugarcane in Madhya Pradesh, India.

4.1. Energy used for mechanized cultivation of sugarcane in Narsinghpur (M.P.) in 2013-14.

In the mechanized farming of sugarcane, the use of operation wise energy sources and their energy use pattern for cultivation of sugarcane in the selected area of study, Narsinghpur during 2013-14 is shown in table. 2.

Item	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Farmer 5
Operation wise energy use MJ/ha					
Seedbed Preparation	5984.33	4818.04	4420.33	3233.72	4420.33
Sowing	43497.6	38153.6	38153.14	38080	40534

Interculture		4882.19	2987.39	1603.84	2405.76	2963.23
Irrigation		103673.9	87390.31	82016.31	82016.31	76157.36
Fertilizer Application		20541	8494	10094	9865	10211
FYM Application		2071.03	-	-	1005.43	-
Plant protection		614.48	-	309.38	260.98	314.76
Harvesting		1176	1176	1097	980	1176
Transportation		10405.15	10405.15	8344.95	5523.50	4185.58
Ratooning		196	196	156.80	147	156.80
Total		193041.69	153620.93	146195.75	143517.7	140119.26
Yield	2013-14	1375	950	750	750	875
q/ha						
Energy ratio		1.88	1.63	1.35	1.38	1.65
Specific energy		2.80	3.23	3.89	3.82	3.20
MJ/kg						
Productivity ratio		0.35	0.30	0.25	0.26	0.31

The irrigation is the main aspect; it has found through survey that for the requirement of the total input energy (MJ/ha) sugarcane cultivation in Narsinghpur during 2013-14.

Table 2, Operation wise energy used for mechanization in sugarcane.

4.1.1. SEEDBED PREPARATION

A well and fine preparation of seed bed is required for sugarcane cultivation. The main achievement in sugarcane mechanization in India to date is in land preparation with the mechanization level of that operation now around 80%. The equipment mainly used includes primary tillage implements like indigenous plough, mould board plough, disc plough, rotavator, duck foot tiller, sub soiler, clod crusher, ridger, bund former and other local available implements and tools. These implements are also performed to develop a desirable soil structure for a seedbed, to provide optimum environmental conditions for plant growth, to minimize soil erosion by following such practices. The energy requirement in mechanization in sugarcane cultivation for seedbed preparation is ranged from 3233.72 to 5984.33 MJ/ha was found during the survey of the selected area of study Narsinghpur, (M.P.). The process of mechanized seedbed preparation with the help of mould board plough attached with tractor is shown in plate 1.



Plate 1.Seedbed preparation for mechanized sugarcane farming.

4.1.2. SUGARCANE PLANTING

The first mechanized operation in the sugarcane cultivation after land preparation is sugarcane planting. The farmers have been following different planting methods viz, flat planting, trench planting, row planting, spaced transplanting and dual row planting by manually and sugarcane cutter cum planter, etc. The row to row space maintained by the farmers is mostly ranging from 60-100 cm, but 75 cm is being the most common by the farmers. The use of energy in planting of sugarcane sets or budded by using tractor operated sugarcane cutter planter was found in range between 38080 to 43497.6 MJ/ha. The many farmers were adopted this machinery for planting of sugarcane it is a time saving or energy efficient machinery. The use of sugarcane cutter cum planter for planting of sugarcane is shown in plate. 2.



Plate.2 Sugarcane cutter cum planter

4.1.3. IRRIGATION

The crop sugarcane was grown by the farmers after paddy crop. It is also cultivated by the farmers had fellow land during kharif. In Narsinghpur “Havelli” system was used in which rainfall water is stored during rainy season. In this system land used to be sloppy at the centre like ponds so, water do not loss by runoff. In the Narsinghpur most of the farmers possessed tube well and the farmers, who did not have water source, hired the irrigation water from neighbouring farms. Higher irrigation energy means either higher number of irrigation or more hours of water supply in each irrigation. In these years the water reached to the plants by free flow. Most of the farms had slope for movement of the water. The variation in irrigation energy was too much and there were few farmers who did not apply any irrigation and totally dependent on winter or summer rains. The results revealed that un-irrigated fields average yield was only 750 q/ha which was less than half of the average yield in the selected area of Narsinghpur. The choice of sugarcane crop by the farmers has been based on availability of assured irrigation sources.

After mechanization in sugarcane farming, the farmers were used improved irrigation systems like, drip irrigation, sprinkler irrigation by using water lifting pump or submersible which are operated by electricity, after applying electricity for lifting water from ground the requirement of electric energy is more in irrigation of sugarcane crop in the Narsinghpur (M.P.) due to higher number of irrigation. The requirement of electric energy for irrigation in sugarcane crop is ranged from

262 76157.36 to 103673.9 MJ/ha and increase 20-25 % yield of sugarcane crop.
 263 Sprinkler irrigation system is most common irrigation system which are adopted
 264 approximately 85-90% farmers in Narsinghpur (M.P.) the sprinkler irrigation system
 265 for sugarcane crop is shown as following Plate 3.



266
 267

268 **Plate3.** Sprinkler irrigation system for sugarcane

269 **4.1.4 INTERCULTURE**

270 The mechanical intercultural operations required in sugarcane crop are weed
 271 control, moisture conservation and creation of better environment for overall growth
 272 of plant. After emergence, weeding is done with the help of tractor drawn or animal
 273 drawn cultivators. Tractor drawn cultivators can effectively be used by adjusting the
 274 spacing between the tines as per the row to row spacing of the crop, use of wheel
 275 hoe, use of dry land power weeder, use of self-propelled rotary weeder and light
 276 weight power tiller. During the study of mechanization in sugarcane cultivation in the
 277 selected area Narsinghpur, it is observed that intercultural required approximately
 278 2694.96 MJ/ha under the tractor farming. Bullock farming is not considered as
 279 numbers of observation were low. The result approves the information derived from
 280 the selected area Narsinghpur. The yields under the bullock farming were 625 q/ha
 281 as compare to 1375 q/ha under tractor farming. The output-input energy ratio was
 282 1.88 and 1.37 for mix and tractor farming and their respective values for specific
 283 energy were 3.89 and 2.90 as stated earlier mix farmer used comparatively higher
 284 physical inputs like chemical fertilizer as compared to tractor farmers.

4.1.5. HARVESTING

Manual harvesting of sugarcane is vogue in Narsinghpur. Different types of sugarcane harvesting knives of different size, shape and weight are being used for sugarcane harvesting at different places in Narsinghpur. Sugarcane harvesting manually by traditional tools is highly labour intensive and costly operation out of all sugarcane production practices. About 850-1000 man-hour per ha is required for sugarcane harvesting with the traditional tools. The energy involved in harvesting of sugarcane is 1176 MJ/ha in the selected area of study Narsinghpur. More advanced machines are now available (Sugarcane Harvester), which cut the cane stalk at the base. The cut canes are placed in a single windrow from 4-6 rows. Subsequently, depending upon the availability of the labour, mechanical loaders/manual loaders can be employed for loading purposes. 8-10 % of the trash remains in the harvested cane. The farmers were used mechanized harvesting for sugarcane crop by using improved sugarcane harvester shown in plate 4, it consumes 7380.50 MJ/ha energy during the process of harvesting of sugarcane crop in the Narsinghpur (M.P.).



Plate 4. Sugarcane harvester

4.1.6. RATOONING

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. The total energy involves in ratooning process after harvesting the sugarcane crop is found 1960 MJ/ha 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.

4.1.7. TRANSPORTATION

Transportation process is the last process of sugarcane is to carry the bundle of sugarcane from field to sugar industries. Trucks, tractors and other vehicles can be used for transporting the sugarcane stalks or billets to sugar industries. Loading and transporting machines used for sugarcane crop. The energy involves in the process of transportation of sugarcane is 4185.58 to 10405.15 MJ/ha due to distance issue from field to industry/mill. The process of manually loading of sugarcane for transportation is shown in plate 5.



Plate 5. Loading of sugarcane for transportation

CONCLUSION

Mechanization means better management of physical inputs, 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-input energy ratio and yield for the production of sugarcane in Narsinghpur. The use of total energy was highest in tractor farms followed by the animal farms for sugarcane cultivation, tractor farms were followed by animal farms. On an average the tillage consumption was 4607.47 MJ/ha for mix farming the corresponding yield was 2575 q/ha in 2013-14 respectively. Hence, there is a direct co-relation between tillage energy consumption, bullock and tractor farming. The growth rate of sugarcane crop was highly significant compared to other crop in Narsinghpur after mechanization.

REFERENCE

- [1] Abhyankar A. Use of chemical fertilizer energy in Indian farming and ways to improve its application. Indian, Fertilizer Scene. Annual. 2003;3(3):35-43.
- [2] Braunbeck O A and Magalhaes P S G. 2014. Technological evaluation of sugarcane. mechanization. 451-464.
- [3] Verma Mrinal and Tripathi Ashok. 2015. Perspective of Agricultural Mechanization in Supaul District of North Bihar- A Research. IOSR Journal of Agriculture and Veterinary Science. 8(8): 4-12.
- [4] Kumar Avinash, Shrivastav Atul Kumar and Patel Aaradhana. 2018. Assessment of Energy Use Pattern in Different operations from Various Sources for Cultivation of Sugarcane in the District of Narsinghpur, Madhya Pradesh, India. Current Journal of Applied Science and Technology. 28(1): 1-9.
- [5] Anonymous 2013. Sugarcane cultivation in India. Chapter 4.
- [6] Khandelwal NK, Raghuvanshi KK. Energy use pattern for Soybean crop production in Satpura-Kymore plateau, State of Madhya Pradesh, College of Agricultural Engineering JNKVV Jabalpur; 1985.
- [7] Anonymous. Status of sugarcane share in Indian agriculture.
- [8] Anonymous 2012. Sugarcane status in Narsinghpur, MP.

357 <http://narsinghpur.nic.in/profile.html>.

358 [9] Anonymous 2012. District-wise Area, Production & Yield - Government of

359 Madhya

360 Pradesh. <http://www.mp.gov.in/en/mp-krishi/arg-st/districtwisearea>