Requirement of Energy for Mechanized Cultivation of Sugarcane in Narsinghpur, (M.P.), India

Avinash Kumar[1*], Aaradhana Patel[2], Atul Kumar Shrivastava[1] and N.K. Khandelwal[1]

[1]Department of Farm Machinery and Power Engineering, College of Agricultural Engineering, Jawaharlal Nehru KrishiVishwaVidyalaya, Jabalpur, Madhya Pradesh 482004, India.
[2]Department of Post Harvest Process and Food Engineering, College of Agricultural Engineering, Jawaharlal Nehru KrishiVishwaVidyalaya, Jabalpur, Madhya Pradesh 482004, India.

Author's contributions:

This work was carried out in collaboration between all authors. Author AK and Author AP designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author AKS guided the analyses of the study. Author AKS and NKK managed the literature searches. All authors read and approved the final manuscript.

ABSTRACT

The purpose of this study was to determine the requirement of the energy for mechanization in sugarcane which was involved in the 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 implied 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 requirement of energy for sugarcane production was highest as compared to many other crops such as potato, maize, wheat, paddy, sorghum etc. Sugarcane was labour intensive crop requiring about 3300 man-hrs per hectare for different operations. Considering the present trend of the availability of labour for sugarcane production, it had been experienced that the use of modern machinery was inevitable. However, the adoption of these implements and machinery have not been up to the desired level. Thus there was a considerable mechanization gap, especially in the area of sugarcane planting, intercultural, plant protection, harvesting and ratoon management. This study dealt with the whole process of developing mechanization and describes the requirement of energy for mechanization of sugarcane in Narsinghpur, (M.P.) India.

Keywords: Mechanization;sugarcane; Narsinghpur;cultivation of sugarcane; requirement of energy sources.

1. INTRODUCTION

Energy is the key to Life. Energy comes from food and thus from agriculture. Agriculture depends on energy input. The energy capacity

**Corresponding author: E-mail: avinash255075@gmail.com;*
Name – Avinash Kumar

for activity. Survival, convenience and comfort of human being depends on how best the energy is captured transformed and utilize. To identify the energetic relationships of the agricultural system 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 replace or aids manual and animal work, it can be said that it is necessary for 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 field to mill/industries, 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 increase. 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 a 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 intrasystem allocation of energy resources. The study which constitutes the subject matter, 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 sectors 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 Indian geographical area and is contributing 16.1% of Indian GDP. Agriculture still contributes significantly to India's GDP despite the decline of its share in Indian GDP [5]. There is a number of crops grown by farmers. These include different food crops, commercial crops, oil seeds etc., sugarcane is one of the important commercial crops grown in India [6].

Sugarcane is 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. During the period between the harvest of the last cycle and the planting of the new one, some mills do crop rotation with legume species [7]. Cane harvesting used to be traditionally done manually, but it has witnessed a rapid transformation in the last decade due to mechanical harvesting, mainly as a response to environmental legislation that restricts the use of field burning. Major sources of farm power include both animate (humans and draught animals) as well as inanimate sources such as diesel engines, tractors and electric motors [6,8].

Sugarcane is a most important cash crop of India. It involves less risk and farmers are assured up to some extent about return even in adverse condition. In the agriculture sector, sugarcane shared 7% of the total value of agriculture output and occupied 2.6% of Indian gross cropped area during 2006-07. Sugarcane provides the raw material for the second largest agro-based industry after textile. About 527 working sugar factories were located in the country during 2010-11 with a total crushing capacity of about 242 lakh tonnes [9].

The energy requirements in various facets of agriculture (including livestock production and household's activities) vary considerably due to variations in the technology level adopted by the farmers and also because of the diverse agro-climatic conditions. Technology level and agro-climatic conditions constitute the most important factors pertinent in the production of a crop in the state of Madhya Pradesh. Agriculture is the main source of income of the majority of the population of the state [10].

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 level. Narsinghpur is a district, which is well known for its fertile land, it is said to be the most fertile land all over Asia. Black soil suited for any kind of cultivation blessed with adequate irrigation facilities. The district is famous for its rich agricultural production. Being situated in the upper part of Narmada Valley, which is much important for agriculture [11]. 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 Plough, Bullock Carts, Bakhar, Hansiya, khurpi and various types of knives etc. In new methods or techniques thrashers, tractors, harvesters, electric pumps and sprinklers etc. Along with these better quality seeds and best quality pesticides are used. The area covered for sugarcane production was 24 thousand hectares and the corresponding yield was 4386 Kg/ha during the year 2009-10 [9,12].

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 [13]. 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 involves heavy physical work. A number of labour saving machines and tools have been developed for various farm operations [14].

2. MATERIALS AND METHODS

2.1 Selection of Villages and Collection of Data

Villages were selected on the basis of a 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.
- ✓ Landholding should be well distributed under a different category.
- ✓ The urban effect should be minimum.
- ✓ Co-operation of the resident of the village should be proper.
- ✓ The village should be well connected by road.

Data were collected on the pre-tested proforma by a combination of interview method and by taking an actual measurement. The physical data were converted to a common denominator by multiplying them with the appropriate energy equivalent coefficient. 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 ware contacted to have required information in present proforma. The information was included with the quantity of energy input in the form of seed, fertilizer, chemical, irrigation, human, animal and prime movers. The output in the form of yield and by-products are to be determined from all the farmers of the villages falling into different categories, further cropping pattern 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 inventory of all farm machinery in the farm of 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.

2.2 Specific Energy

The 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 the primary product. It is calculated by dividing the total input energy by the yield of the main product and represent as MJ/kg.

2.3 Energy Calculation for Mechanized Cultivation for Sugarcane

The energy used in the particular field operation was calculated by sum of human, animal, mechanical and electrical energy consumption. 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. The energy calculation for the mechanized cultivation of sugarcane by operation wise energy and its use

pattern including with all operations like; seedbed preparation, sowing, intercultural, fertilizer application, irrigation, harvesting, transportation and rationing etc.

2.4 Statistical Analysis

The energy data were 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:

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

Where,

SD = Standard deviation = $(x_i - x)^2$

n_1 = Number of samples of mean x_1

n_2 = Numbers of samples of mean x_2

3. RESULT S AND DISCUSSION

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

India occupies the second rank in the 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.

3.1 Energy use 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 are shown in the Table 1.

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

3.1.1Seedbed 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 an 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 for 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 a tractor is shown in plate 1.

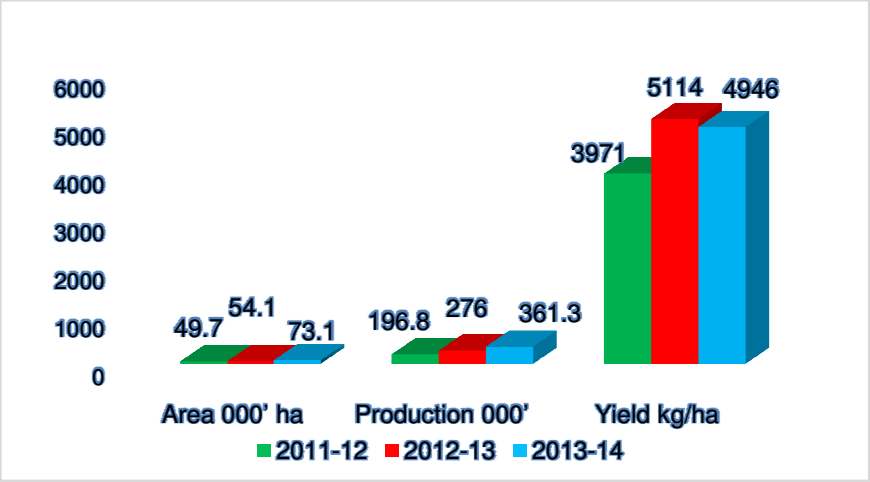

Fig. 1. Production, yield and area of Sugarcane in Madhya Pradesh, India

Table 1. Operation wise energy used for mechanization in sugarcane

Item	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Farmer 5
Operation wise energy use MJ/ha					
SeedbedPreparation	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
FertilizerApplication	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 q/ha 2013-14	1375	950	750	750	875
Energy ratio	1.88	1.63	1.35	1.38	1.65
Specific energy MJ/kg	2.80	3.23	3.89	3.82	3.20
Productivity ratio	0.35	0.30	0.25	0.26	0.31

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Plate 1. Seedbed preparation for mechanized sugarcane farming

3.1.2 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 the planting of sugarcane sets or budded by using tractor operated sugarcane cutter planter was found in the range between 38080 to 43497.6 MJ/ha. The many farmers have 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.

3.1.3. Irrigation

The sugarcane was grown by the farmers after paddy crop. It is also cultivated by the farmers had fellow land during kharif season. In Narsinghpur "Havelli" system was used for irrigation in which rainfall water is stored during the rainy season. In this system land used to be sloppy at the centre like ponds so, water does not loss by runoff. In the Narsinghpur most of the farmers possessed tube well and the canals, who did not have water source, hired the irrigation water from neighbouring farms. Higher irrigation energy means either a higher number of irrigation or more hours of water supply in each irrigation. In these years the water reached the plants by the free flow. Most of the farms had a 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 were found 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 the 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 76157.36 to 103673.9 MJ/ha and increase 20-25 % yield of sugarcane crop. Sprinkler irrigation system is the most common irrigation system which are adopted approximately 85-90% farmers in Narsinghpur (M.P.) the sprinkler irrigation system for sugarcane crop is shown as following Plate 3.

3.1.4 Interculture

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

3.1.5. Fertilizer, FYM and pesticide application

In sugarcane, weeds have been estimated to cause 12 to 72 % reduction in cane yield depending upon the severity of infestation. The nature of weed problem in sugarcane cultivation is quite different from other field crops because of the reasons sugarcane is planted with relatively wider row spacing, the sugarcane growth is very slow in the initial stages. The fertilizer energy involved in the mechanized cultivation of sugarcane was 20541 MJ/ha by manually broadcasting of fertilizer (NPK). The contribution of FYM and pesticides energy in the mechanization of sugarcane was found very important for better growth and save from various type of disease which was affect the sugarcane

Plate 2. Sugarcane cutter cum planter

Plate3. Sprinkler irrigation system for sugarcane

crop. The energy involved in FYM and pesticides application was found 2071.03 MJ/ha and 614.48 MJ/ha.

4.1.6. 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 involves in the 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.).

3.1.7. Ratooning

Ratooning is a method where the lower parts of the plants along with the roots are left uncut at

Plate 4. Sugarcane harvester

Plate 5. Loading of sugarcane for transportation

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 and fertigation etc.

3.1.8. 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 the field to industry/mill. The process of manually loading of sugarcane for transportation is shown in plate 5.

4. CONCLUSION

Mechanization meansbetter 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. The demand of total energy which was required for sugarcane cultivation from seedbed preparation to ratooning of the sugarcane crop in the selected area of study was 193041.69 MJ/ha. 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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