

Original Research Article

Assessment of energy use pattern in different operations from various sources for cultivation of sugarcane in the district of Narsinghpur, Madhya Pradesh

ABSTRACT

The production and productivity are directly related use in unit operation of agricultural production. The variation in yield of crop occurs in Narsinghpur District of Madhya Pradesh due to in wide variation in energy inputs, agro-climatic conditions and resources used. Keeping this in view, the present study deals with energetics of sugarcane in the district of Narsinghpur, Madhya Pradesh, for getting higher energy input. In the selected area, all the physical inputs in the form of direct and indirect sources and output in the form yield of grain and by-product are converted into common units of energy (MJ) per unit area (ha). The trend of use of direct energy (human, mechanical, Electrical etc. and indirect energy seed, fertilizer, chemical etc. was studied for performing different field operations from tillage to transport operations). The most energy consuming operation was irrigation, it consumed about 79056.13 MJ/ha and it consumed 51 per cent of total energy. Among physical input the fertilizer contributed maximum energy and its maximum energy value was 61200 MJ/ha where as some farmers were found using less than 23485.5 MJ/ha of the total energy input.

KEYWORDS:

Sugarcane, Narsinghpur, Energy, Energy Sources, Production, Productivity, Energy Input.

INTRODUCTION:

The state of Madhya Pradesh is situated in the heart of India between latitude 21 degree to 26-degree N and longitude 74 degree and 81-degree E. The mean temperature varies from less than 10 degrees Celsius to more than 46 degrees Celsius during winter and summer respectively. The annual rainfall varies from below 800mm in the western part of the state, to be above 1600mm in the eastern region [1].

19 The estimated population of the state is 79.9-millions with a density of 236
20 persons per sq. km. There is a variety of soil type ranging from lateritic through
21 mixed red and black-to-black soils of different depths. The net-cropped area of the
22 state is 19.89 million hectares, of which only 5.6-million-hectare land is irrigated. The
23 cropping intensity of the state is 132 per cent, which is below national average of 135
24 per cent [2,3].

25 Energy plays a major role in national development process and in providing
26 major vital service that improve human condition – fuel for cooking, light for living,
27 and motive power for transport and electricity for modern communication. In
28 agricultural sector energy is used in every form of inputs – human and animal power,
29 seed, fertilizer, agro chemical for plant protection, machinery use for various
30 operations being operated by electricity and fossil fuels, biomass and coal for living,
31 and is directly linked with technological process [4].

32 **Sugarcane (*Saccharum officinarum* L.)** an old energy source for human
33 beings and more recently, a replacement of fossil fuel for motor vehicles was first
34 grown in South East Asia. It was introduced to Egypt around 647 A.D. and about one
35 century later to Spain (755 A.D.) [5]. Sugarcane is a major crop grown in both
36 subtropical and tropical belts of the world for production of sugar. The sucrose
37 synthesised in the leaves is transported to the culm or cane for storage. In general,
38 the vegetative growth rate of sugarcane slows down and sucrose content in cane
39 increases approximately by 180 days after planting. Genotype, plant maturity and
40 environment play a significant role in the rate of sucrose accumulation [3, 6].

41 Sugarcane production is expected to be lower at 309 million tonnes (2016-
42 17), compared to 348 million tonnes the year before. Production of cotton is set to
43 increase from 30 million bales last year to 32.5 million bales in 2016-17 (one bale
44 equals 170 kg). However, this is lower than the past record of 35.9 million bales
45 produced in 2013-14 [7].

46 In India, the total area under sugarcane cultivation was reported to be about
47 49.18  hectare. The country produced about 3414.25 lac tonnes of cane at a
48 national average of about 69.42 tonnes/ha in the year of 2015-16 [8]. India occupies
49 the second rank in production of sugarcane in the world and contributes nearly
50 20.4% area and 18.60% production. The major sugarcane growing states are Uttar

51 Pradesh, Maharashtra, Tamil Nadu, Karnataka and Madhya Pradesh etc. The area
52 and production of sugarcane in Madhya Pradesh is about 0.73 lac hectare and 31.73
53 lac tonnes [7].

54 At global level, total 121 countries are producing the sugarcane. Out of them
55 some of important countries like Brazil, India, China, Thailand, Pakistan, Mexico,
56 Cuba, Columbia, Australia, USA, Philippines, South Africa, Argentina, Myanmar and
57 Bangladesh are producing approximately 80% of total world production of sugarcane
58 [8]. Worldwide, sugarcane occupies an area of 20.42 million hectares with a total
59 production of 1333 million metric tonnes. Sugarcane area and productivity differ
60 widely from country to country. Brazil has the highest area i.e. 5.343 million hectares,
61 while Australia has the highest productivity i.e. 85.1 tonnes/ha [5].

62 The energy consumption in production of sugarcane is highest as compared
63 to many other crops such as potato, maize, wheat, rice, sorghum etc. Sugarcane is
64 labour intensive requiring about 3300 man-hrs per hectare for different operations.
65 Considering the present trend of availability of labour for sugarcane production, it
66 has been experienced that the use of modern machinery is inevitable. Use of
67 machinery helps in labour saving and timelines of operations, reduces drudgery,
68 helps in improving quality of work, reduces cost of operation and ensures effective
69 utilization of resources (9, 4).

70 The energy consumption for seed bed preparation and transplanting
71 consumed 66-72 per cent of total energy input in paddy crop production whereas
72 irrigation, seed bed preparation and threshing consumed 70-88 per cent of total
73 energy in wheat crop. Energy output - input ratio was highest for sugarcane crop
74 followed by maize, paddy and wheat [10]. Energy parameters for irrigation treatment
75 in Indian agriculture and reported that irrigation consumed up to 60 per cent of the
76 total energy requirements for crop production under different methods of irrigation.
77 Energy requirements per unit area were highest for sugarcane, cotton, paddy and
78 wheat crops and lowest for maize. Fossil energy is used to a great extent by most of
79 the crops [11].

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83

84 **Table 1.** List of sugarcane varieties used for the study on sugarcane energy used
85 pattern.

Tropical early	Tropical mid- late	Subtropical early	Subtropical mid-late
Co 449	Co 419	BO 43	BO 34
Co 527	Co 740	BO 99	BO 91
Co 775	Co 785	Co 395	Co 312
Co 997	Co 62175	CoJ 64	Co 453
Co 8231	Co 6806	CoP 2	Co 1148
Co 6415	Co 6304	CoP 1	Co 975

86

87

88 MATERIAL AND METHODS:

89 The study has been carried to find out the energy requirement for sugarcane
90 crop in the selected area of study Narsinghpur, Madhya Pradesh. The study deals
91 with the selection of villages and farmers, categorization of farmers/farms and
92 method employed for data collection, analysis and optimization of energy inputs to
93 attain the objectives of the study. The information collected from the farmers was
94 transformed into computer data sheet as per requirement of energy calculation and
95 results were obtained from energy FORTRAN-77 computer software programmes.
96 The analysis carried out in MS Excel and energy assessment was prepared for
97 sugarcane crop. The statistical analysis was performed with SPSS 7.5 computer
98 software programme using linear regression model. The outlier points were
99 removed. After removal of outlier points the energy use pattern and assessment of
100 energy was prepared for sugarcane crop in the Selected area of study Narsinghpur,
101 Madhya Pradesh. The calculation of energy has been done with following objectives.

- 102 1- Selection of villages.
- 103 2- Selection of farmers.
- 104 3- Collection of data.
- 105 4- Classification of energy.
- 106 5- Calculation of energy-
 - 107 5.1- Direct sources of energy.
 - 108 5.2- Indirect sources of energy.

109

110 **Energy from Direct Sources:**

111
$$DE = HLH \times 1.96 + BPH \times 10.01 + FC \times 56.31 + EC \times 11.93 \quad \dots\dots\dots eq. 1$$

112 Where,

113 DE = Direct Energy, (MJ)

114 HLH = Human labour hours use

115 BP = Bullock pair hours used, (h/ha)

116 FC = Fuel consumption, (l/ha)

117 EC = Electricity consumption, (kWh/ha).

118 **Energy from Indirect Sources:**

119
$$IE = (C \times WM \times OA) + FYM \times 0.3 \text{ MJ/kg} + S \times 14.7 \text{ MJ/kg} + Ch$$

 120
$$\times 120 \text{ MJ/l} + \text{fertilizer} (N \times 60.0 + P \times 11.1 + K \times 6.7) \quad \dots\dots\dots eq. 2$$

121 Where,

122 IE = indirect energy input from machinery, (MJ)

123 C = energy coefficient, (MJ/kg)

124 WM = weight of machinery used per hour, (Kg)

125 HUM = hours of use of machinery, (h)

126 OA = operational area, (ha)

127 FYM = Farm Yard Manure, (Kg/ha)

128 S = seed, (Kg/ha)

129 Ch = chemicals, (l/ha)

130 N = nitrogen (kg)

131 P = phosphorus (kg)

132 K = potash (kg).

133 **Total energy:**

134
$$TE = DE + IE \quad \dots\dots\dots eq.3$$

135 Where,

136 DE = Direct Energy, MJ

137 IE = Indirect Energy, MJ

138

139 **Mechanical power:**

140 Fuel consumption of tractor and diesel/petrol engines used for different farm
 141 operations wise calculated by the following equation:

$$F = \frac{LCF \times RHP \times SFC}{1000} \dots\dots\dots \text{eq. 4}$$

Where,

F = Fuel consumption (l/h)

LCF = Load coefficient factor for different farm operations

RHP = Rated horsepower of power source in hp or kW

SFC = Specific fuel consumption (ml/hp/h) or (ml/kWh).

RESULTS AND DISCUSSION:

This study deals with the results obtained from the field studies and its interpretation of the sugarcane cultivation in the Narsinghpur district of Madhya Pradesh. 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, optimization of energy use and prediction of energy requirement from different sources for required yield level of sugarcane for selected area, Narsinghpur district of Madhya Pradesh.

Operation wise and source wise energy use pattern for cultivation of sugarcane:

Operation wise and source wise energy use pattern for cultivation of sugarcane in the selected area is shown in table no. 3. The irrigation is the main aspect it has found through survey that for the requirement of the total input energy (MJ/ha) cultivation of sugarcane.

Energy input (MJ/ha):

In this study heavy dependency was put on irrigation. However, in the survey, irrigation is till the major component to energy but there has been significant improvement in seed bed preparation and sowing resulting in the change in energy used pattern. In order to distinguished between the energy use patterns used by selected area surveys. Table 3. give the details of energy requirement for different operations under different categories of farmers.

Operation wise energy use pattern:

The operation wise energy requirement for sugarcane cultivation varied between 112935.73 MJ/ha to 193041.69 MJ/ha with mean value of 148130.6 MJ/ha. Fig. 1. shows that irrigation required maximum energy (53.36%) followed by Sowing (26.06%), fertilizer application (8.05%), transportation (6.16%), seed bed preparation (3.11%), interculture (1.81%), harvesting (0.73%), FYM application (0.38%), plant protection (0.18%), ratooning (0.11%) respectively the maximum operation wise energy was consumed by medium land holding farmers and it was lowest by small farms. The trend was not normal and it may be due to absence of winter rain for which farmers required maximum energy per unit area for irrigation due to smaller farm area and also hiring of water from neighbour.

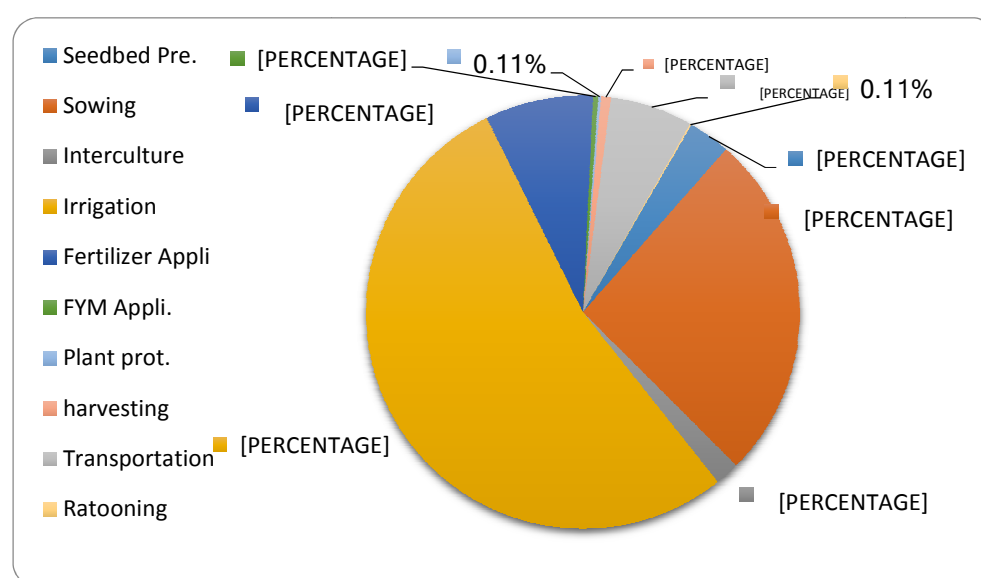


Fig. 1. Operation wise energy use pattern for sugarcane (percentage) in Narsinghpur, Madhya Pradesh.

Source wise energy use pattern:

The main source of energy for production can be direct or indirect in nature the direct sources are those that release energy directly to the system as human and electrical energy etc. These are the most energy supplying sources. Among the indirect sources like seed, fertilizer and chemical supply energy to the system through conversion process. These are useful for plant growth, but work done by the sources can be seen only after completion of conversion process. Machinery is also indirect source as they perform their work, but they are powered by direct sources like diesel and electricity etc. Total energy includes both direct and indirect sources.

Fig. 2. conducted that the highest energy contributing source was electricity. Electricity provided maximum energy i.e. 100122.5 MJ/ha. Irrigation consumed maximum energy but fertilizer used was minimum. This means that there exists no direct relation between irrigation and fertilizer used. The fertilizer contributed only 8.0 per cent of total energy. The survey revealed that, the use of manure was not sufficient in the selected area of Narsinghpur. Total average energy use by all sources were calculated and found to be 148130.6 MJ/ha and minimum of 104908.45 MJ/ha. In most years energy used varied between 104908.45 to 148130.6 MJ/ha.

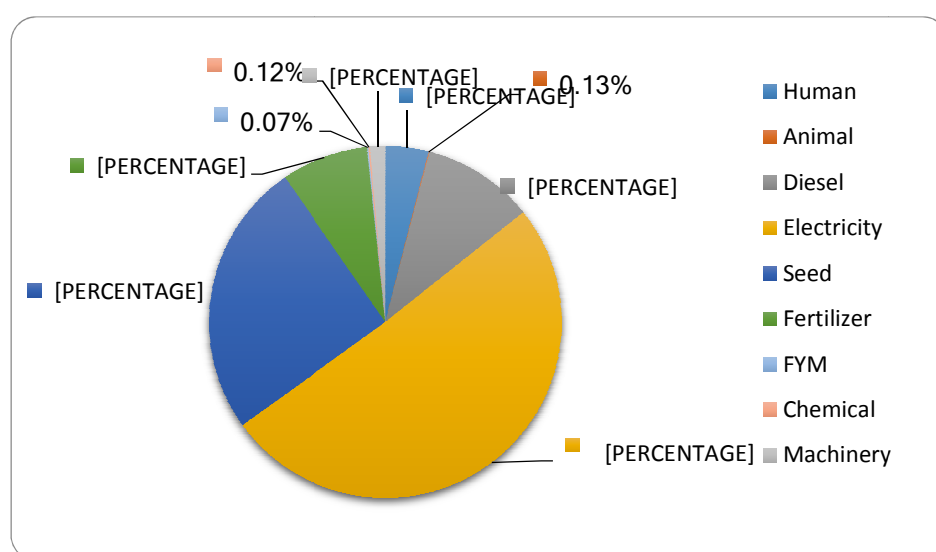


Fig. 2. Source wise energy use pattern for sugarcane (percentage) in Narsinghpur, Madhya Pradesh.

Seed is another energy contributing source in rabi season and sugarcane seed contributed between 33125 to 42400 MJ/ha. It contributed approximately 25 per cent of the total energy. The contribution of diesel was about 10.26 per cent of total. Initially during before nineteenth when bullock farming was common the contribution of diesel was only 2023 MJ/ha. Later years the use of diesel increased to a greater extent. The maximum contribution of diesel was observed during the year i.e 20395.48 MJ/ha, in the present study.

Use of animal was inversely proportional to use of diesel. During the survey it was revealed that, animal contributed 1161 MJ/ha. Human contributed 58192.10 MJ/ha to 48362.6 MJ/ha. As the use of bullocks reduced the use of human labour also reduced. This does not mean that utility of human being reduced, only it can be

said that now it is used for more quality work than for laborious work. Its contribution was 3.92 per cent. Overall it contributed 4.37 per cent of the total energy.

Use of machinery varied between 17611.1 MJ/ha to 20748.9 MJ/ha. As use of tractor drawn heavier implements increased the energy contribution by machinery increased. Total energy contribution by various sources varied between 20748.9 MJ/ha to 17611.10 MJ/ha. The variation occurs mainly due to variation in energy contribution by electricity and fertilizer. The per cent change in energy supplies for sugarcane production through different sources.

Table. 3. shows that the total energy input from different sources was 148130.6 MJ/ha. The variation among the total energy input on the different farmers was 104741.88 to 148130.6 MJ/ha. The total energy consumed by large farmers (148130.6 MJ/ha) was found to be higher than that of small (104741.88 MJ/ha). Electricity and diesel contributed 50.76 and 10.26 per cent of total energy. Electricity operation was used for irrigation whereas diesel was used mainly for tillage or transportation. The energy inflow through electricity was 75191.32 MJ/ha followed by diesel 15211.46 MJ/ha. Among the indirect source of energy, the fertilizers supplied maximum (20400 MJ/ha). The policy on electric traffic for agricultural use has been varying. The past trend being provision of free electricity. Such policy defines to a great extent the pattern of use of electricity.

Effect of irrigation on the yield of sugarcane:

The relationship between yield and irrigation energy is also considered. The effect of irrigation for the selected area Narsinghpur can be detailed as below:

Narsinghpur:

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. The relation between irrigation energy and yield is shown in fig. 5. for the selected area Narsinghpur.

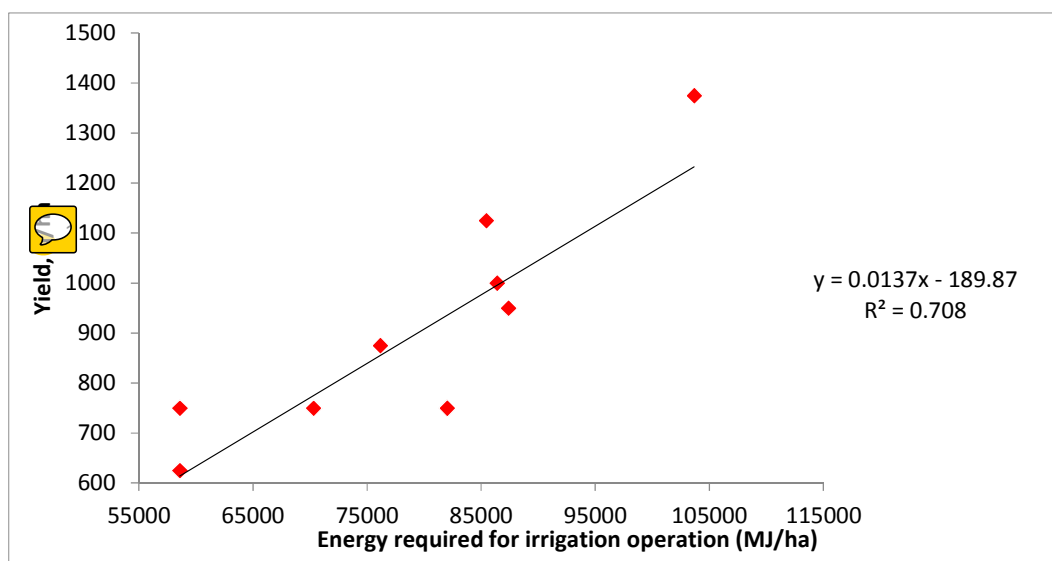


Fig. 3. Effect of irrigation on the yield of sugarcane.

By considering irrigation energy as predictor and yield as response they can be correlated with the following equation.

$$y = 0.0137x - 189.87 \quad \dots\dots\dots\text{eq. 5}$$

$$(R^2 = 0.7086)$$

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 625 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. The farmers without assured irrigation did not inclined to select sugarcane crop rather they selected other crop like; wheat, black gram, green gram etc. These relations were found stronger when the data of farmer's survey of the study was considered.

CONCLUSION:

The use of direct energy was comparatively very high as compared to indirect energy in early surveys. The direct-indirect energy ratio was 3.62 from the total

energy input. 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 energy productivity ranged from 0.25 kg/MJ to 0.35 kg/MJ, 0.41 kg/MJ to 0.53 kg/MJ and 0.30 kg/MJ to 0.41 kg/MJ for sugarcane crop. Irrigation was found to be the highest energy consuming operation across selected area under study. Specifically, it consumed about 79056.13 MJ/ha and 237168.39 MJ/ha. Among various operations, irrigation, consumed maximum energy ranged between 51 to 63 per cent while considering the reference of the survey.

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Item		Farmer 1	Farmer 2	Farmer 3	Farmer 4	Farmer 5	Farmer 6	Farmer 7	Farmer 8	Farmer 9	Farmer 10	Average
Operation wise energy (MJ/ha)												
Seedbed Preparation		5984.33	4818.04	4420.33	3233.72	4420.33	5953.09	3957.49	5396.2	4280.10	3571.09	4607.47
Sowing		43497.6	38153.6	38153.14	38080	40534	40926	38080	40730	33909	34105	38616.83
Interculture		4882.19	2987.39	1603.84	2405.76	2963.23	3241.96	872.45	3241.96	2623.87	2127.03	2694.96
Irrigation		103673.9	87390.31	82016.31	82016.31	76157.36	85446.31	70299.71	86394.8	58583.11	58583.11	79056.13
Fertilizer Application		20541	8494	10094	9865	10211	20541	11665	12047	7899	7899	11925.5
FYM Application		2071.03	-	-	1005.43	-	1426.46	-	1186.79	-	-	568.97
Plant protection		614.48	-	309.38	260.98	314.76	512.8	230.9	512.8	-	-	275.61
Harvesting		1176	1176	1097	980	1176	1176	980	1176	980	980	1089.70
Transportation		10405.15	10405.15	8344.95	5523.50	4185.58	4185.58	7432.17	22916.61	12386.94	5523.50	9130.91
Ratooning		196	196	156.80	147	156.80	156.80	196	156.80	156	147	166.52
Total		193041.69	153620.93	146195.75	143517.7	140119.26	163575	133713.72	173768	120818	112935.73	148130.6
Source wise energy (MJ/ha)												
Human		6096.4	4469.78	5147.83	5869.22	5584.53	9927.89	5752.6	5599.72	4936.26	4807.88	5819.21
Animal		-	404	-	-	-	-	606	-	151	-	116.10
Diesel		20395.48	17141.89	14540.36	10703.4	10443.25	13072.36	9960.11	29210.81	16538.24	10108.77	15211.46
Electricity		100122.5	84430.8	77873	77873	72310	77873	66748.3	83435.4	55623.6	55623.6	75191.32
Seed		42400	36437.5	36437.5	37100	39750	39750	37100	39750	33125	33125	37497.50
Fertilizer		20400	8415	10015	9818	10123	20400	11577	11959	7828.5	7828.5	11836.40
FYM		600	-	-	300	-	450	-	450	-	-	180.00
Chemical		538	-	150	180	303	360	150	360	-	-	204.10
Machinery		2491.45	2321.96	2032.95	1674.14	1605.49	1741.88	1819.91	3003.36	2615.79	1442.05	2074.89
Total		193041.69	153620.93	146195.64	143517.7	140119.26	163575.11	133713.72	173768	120818	112935.73	148130.6
Grand total		386083.38	307241.86	292391.39	287035.4	280238.52	327150.11	267427.44	347536	241636	225871.46	296261.2
Yield	q/ha	1375	950	750	750	875	1125	750	1000	625	750	895.00
Energy ratio		1.88	1.63	1.35	1.38	1.65	1.82	1.48	1.52	1.37	1.75	1.60
Specific energy MJ/kg		2.80	3.23	3.89	3.82	3.20	2.90	3.56	3.47	3.86	3.01	3.31
Productivity ratio		0.35	0.30	0.25	0.26	0.31	0.34	0.28	0.28	0.25	0.33	0.30

312 **Table. 3.** Operation wise or source wise energy (MJ/ha) used in Narsinghpur district of Madhya Pradesh.

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