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COMPUTER PROGRAM FOR ENERGY REQUIREMENT OF SUGARCANE PRODUCTION

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Abstract: A user-friendly computer program is developed in Visual Basic environment to determine the energy requirement for sugarcane production and other related terms such as energy ratio, specific energy and output energy. Program is also capable to compute renewable / non-renewable and commercial / non-commercial source of energy. The input parameters of the developed program are mainly human (h), diesel (lit.), electricity (kWh), seed (kg), farm yard manure (kg), fertilizer (kg), chemical (kg), machinery (h), number of human labours and yield (kg/ha). The total energy is being calculated with the help of energy equivalents which are already fed in programme for sugarcane crop. The developed program successfully calculates the energy consumption in MJ/ha. The program could prove to be a useful tool for suggesting sugarcane growing farmers the future need of energy input by analysing season to season data.

Key words: *computer program, energy requirement, sugarcane*

INTRODUCTION

Agriculture is both a producer and consumer of energy. It uses large quantity of locally available non-commercial energy (seed, manure, animate energy etc.) as well as commercial energy (diesel, electricity, fertilizers, plant protection chemicals, machinery etc.) directly and indirectly. Efficient use of these energies help to achieve increased production and productivity and contributes to the profitability and competitiveness of agriculture sustainability in rural living [1].

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Sugarcane (*Saccharum officinarum*) is a widely grown crop in India having 5.03 million-hectare area under cultivation during the year 2013-14. It is an energy intensive crop requiring high input of natural resources especially fossil energy and irrigation water. Earlier studies showed that major energy inputs on farms were derived through farm machinery and equipment, use of petroleum products (directly as diesel or indirectly through fertilizers), tube well irrigation using electricity [2]. About 60% of the world's sugar is supplied from sugarcane production and the rest is produced from sugar beet [3].

To propagate sugarcane crop, stem cuttings (setts) are planted. The first crop, called plant cane, is harvested after 12-16 months. 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 first ratoon crop is harvested after 10-12 months and five to six ratoon crops are common [2].

Singh et al. [4] evaluated the energy requirements of rice, maize, wheat, groundnut, sugarcane, cotton and gram in Indian conditions. The study deals with energy consumption for production of these crops in different states of India. It also highlights the future energy needs to achieve desired yield levels and production targets. Finally, it was concluded that as the energy input increased, the production also increased. Several other studies on energy utilization, energy input-output analysis and their relationships, mostly concentrated on field crops, have been conducted on agricultural production.

Punjab is one of the most important agricultural production province in India. Different geographical and climatic characteristics increase the variety of crop patterns, and irrigated farms have an important economic value in the province. Sugarcane is one of the energy intensive crops of Punjab region. The main objective of the present research was to develop a computer program for calculating energy requirement, to investigate the energy use patterns and to analyze energy input-output in the production of sugarcane. Keeping these facts in mind, the present study helps in keeping record of energy requirement season by season which is easily calculated by the developed program.

MATERIAL AND METHODS

Theoretical consideration. All inputs were converted to energy units using the energy equivalents reported in Tab. 1. These coefficients were adapted from several literature sources that best fit in the Indian conditions.

Table 1. Energy equivalents of inputs in sugarcane production required quantity in sugarcane production

required quantity in sugarcane production			
Input	Units	MJ/unit	References
Human	hour	1.96	[1]
Diesel	litre	56.31	[5]
Electricity	kWh	11.93	[5]
Seed	kilogram	5.3	[3]
Farmyard manure	kilogram	60.6	[7]
Chemical	kilogram	20.9	[6]

Machinery	hour	68.4	[6]
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Energy sources grouped under different categories of energy in which direct energy include human, diesel, electricity, etc. and in indirect energy include seed, FYM, chemicals, machinery etc. Renewable source of energy is the energy source, which can be subsequently replenished and vice-versa for non-renewable energy source. The energy source which are available cheaply are called non-commercial source of energy whereas the others which are capital intensive are called commercial energy source.

$$\text{Output Energy (MJ/ha)} = Y \times E \quad (1)$$

where:

Y (kg) - Yield of sugarcane,
E (MJ/unit) - Energy equivalent of sugarcane,

$$\text{Energy Ratio} = OE / IE \quad (2)$$

where:

OE (kg) - Yield of sugarcane,
IE (MJ/ha) - Input energy,

$$\text{Specific Energy (MJ/kg)} = Y / TE \quad (3)$$

where:

Y (kg) - Yield of sugarcane,
TE (MJ/ha) - Total Energy or Input Energy,

$$\text{Renewable energy (MJ/ha)} = H + S + FYM \quad (4)$$

$$\text{Non-renewable energy (MJ/ha)} = D + E + F + C + M \quad (5)$$

$$\text{Commercial energy (MJ/ha)} = D + E + F + C + M + S \quad (6)$$

$$\text{Non-commercial energy (MJ/ha)} = H + FYM \quad (7)$$

where:

H (MJ/ha) - Energy from human labour,
S (MJ/ha) - Energy from sugarcane stem or seed,
FYM (MJ/ha) - Energy from farm yard manure,
D (MJ/ha) - Energy from diesel consume in sugarcane production,
E (MJ/ha) - Energy from electricity,
F (MJ/ha) - Energy from fertilizer,
C (MJ/ha) - Energy from chemical,
M (MJ/ha) - Energy from machinery like tractor etc.,

Input Parameters. The input parameters for the developed computer program are mainly divided in two parts, namely energy equivalents and required quantity in sugarcane production per hectare. The quantity in sugarcane production inputs include human (h), diesel (lit.), electricity (kWh), seed (kg), FYM (kg), fertilizer (kg), chemical (kg), machinery (h), number of human labours and yield (kg/ha). Beside the input group, the energy equivalents are displayed which was used in the program. The program window for input parameter is shown in Fig. 1. The input data as per parameters discussed was taken only for indication purpose. Sugarcane production system include operations like, seedbed preparation, planting, bund making, irrigation, weeding, fertilizer application, spraying, cutting and cleaning, transportation, post-harvest

activities etc. For energy calculation i.e. source wise energy including direct and indirect energy, subtotal of energy (MJ/ha), total energy requirement (MJ/ha), output energy (MJ/ha), energy ratio and specific energy (MJ/ha), a separate output table is created which is shown in Fig. 2. The flow chart of the developed program is shown in the Fig. 3.

Energy Equivalent in Sugarcane Production		Required Quantity in Sugarcane Production	
Input	Energy Equivalent(MJ/unit)		
Human (h)	1.56	Human (h)	237.53
Diesel (lit.)	36.31	Diesel (lit.)	237.50
Electricity (kWh)	11.93	Electricity (kWh)	320
Seed (kg)	5.3	Seed (kg)	8562
Farmyard Manure (kg)	0.3	Farmyard Manure (kg)	3312.10
Fertilizer (kg)	60.6	Fertilizer (kg)	193.63
Chemical (kg)	20.9	Chemical (kg)	33.40
Machinery (h)	60.4	Machinery (h)	25
		Nos. of Human Labours	5
		Yield	70298

Figure 1. Program window for the input parameters

Source wise Energy, MJ/ha		Output Energy	
Direct Energy		Output Energy	3,72,579.40 MJ/ha
Human	2,327.79	Energy Ratio	4.66
Diesel	13,373.63	Specific Energy	1.14 MJ/ha
Electricity	3,817.60	Renewable Energy	48,700.02 MJ/ha
Sub Total	15,519.02	Non-Renewable Energy	31,333.26 MJ/ha
Indirect Energy		Commercial Energy	76,711.86 MJ/ha
Seed	45,378.60	Non-Commercial Energy	3,321.42 MJ/ha
Farmyard Manure	993.63	Total Energy (MJ/ha)	80,033.29
Fertilizer	11,733.98		
Chemical	698.06		
Machinery	1,710.00		
Sub Total	60,514.27		

Figure 2. Program window for the output parameters

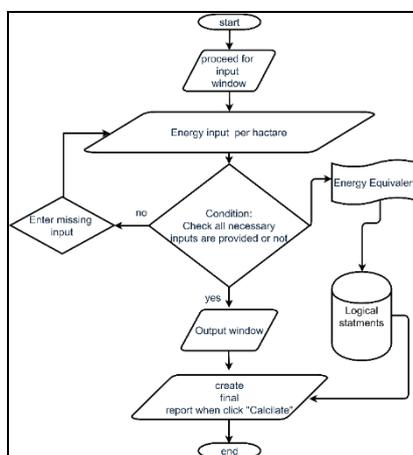


Figure 3. Flow chart of the developed program
RESULTS AND DISCUSSION

General Inputs of Software. Starting from the sugarcane season, input data is to be taken. In the present study, the indicative data per hectare is tabulated in Table 2.

General Outputs of Software. The software output for these runs is given in Table 3. Table indicates that the developed program is capable of calculating all components of energy requirement for sugarcane production.

Table 2. Input parameters

Quantity for sugarcane production(Indicative)	
Input	Quantity per unit area (unit/ha)
Human (h)	237.53
Diesel (L)	237.50
Electricity (kWh)	320.00
Seed (kg)	8562.00
Farmyard Manure (kg)	3312.10
Fertilizer (kg)	193.63
Chemical (kg)	33.40
Machinery (h)	25.00
Number of human labor	5.00
Yield(kg/ha)	70298

Table 3. Output results as calculated by software

Source wise energy, MJ/ha	
Direct Energy	
Human	2327.79
Diesel	13373.63
Electricity	3817.60
Sub-total	19519.02
Indirect Energy	
Seed	45378.60

Farmyard Manure	993.63
Fertilizer	11733.98
Chemical	698.06
Machinery	1710.00
Sub-total	60514.27
Total Energy required = 80033.29	
Output Energy (MJ/ha)	372579.40
Energy Ratio	4.66
Specific Energy (MJ/kg)	1.14
Renewable Energy (MJ/ha)	48700.02
Non-renewable Energy (MJ/ha)	31333.26
Commercial Energy (MJ/ha)	76711.86
Non-commercial Energy (MJ/ha)	3321.42

Source wise percentage share energy for sugarcane is presented in Fig. 4. From the chart, it is clearly indicated that seed (57%) is major source of energy followed by diesel (17%) and fertilizer (14%). Rest is electricity (5%), human (3%), machinery (2%), chemical (1%) and farm yard manure (1%). Fig. 5 shows percentage share by renewable (61%) and non-renewable source of energy (39%) and Fig. 6 shows that share of commercial and non-commercial source of energy is 61% and 39% respectively.

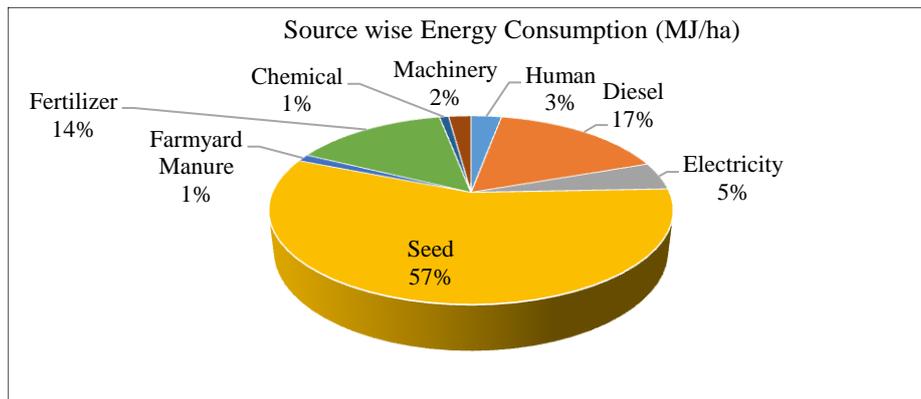


Figure 4. Source wise energy consumption in sugarcane production system

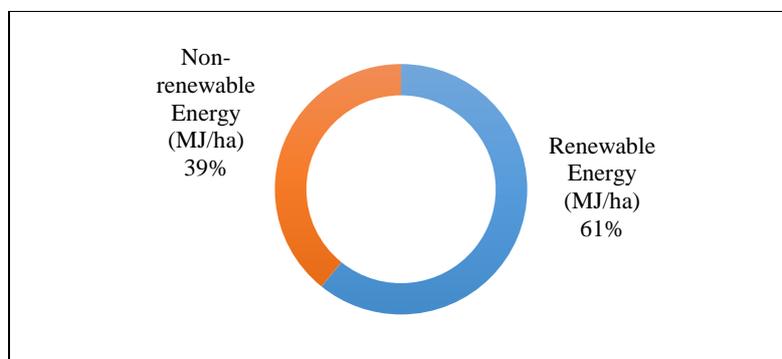


Figure 5. Share of renewable and non-renewable energy sources

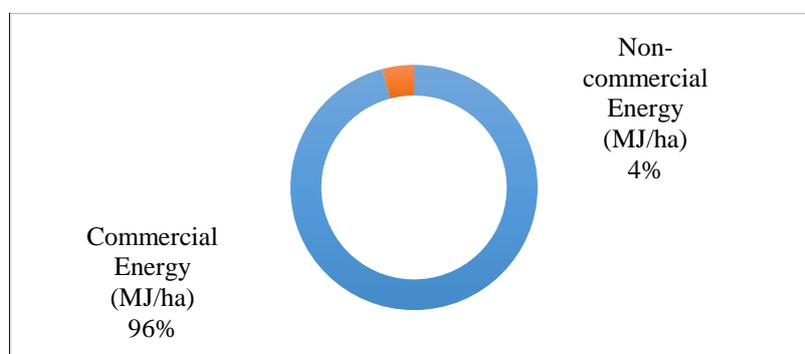


Figure 6. Share of commercial and non-commercial energy sources

CONCLUSION

The developed software is capable to calculate energy requirement in MJ/ha of different source of energy and also calculate output energy, energy ratio and specific energy. This program could prove to be useful to track record of energy use season by season and on the basis of that one can estimate future energy requirement which would help farmer in decision making.

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RAČUNARSKI PROGRAM ZA ENERGETSKE POTREBE PROIZVODNJE ŠEĆERNE TRSKE

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Sažetak: Računarski program prilagođen korisnicima je razvijen u Visual Basic okruženju, za određivanje energetske potrebe proizvodnje šećerne trske i pripadajućih vrednosti kao što su: odnos energije, specifična energija i izlazna energija. Program takođe može da izračuna i obnovljive / ne-obnovljive i komercijalne / ne-komercijalne izvore energije. Ulazni parametri razvijenog programa su ljudi (h), diesel gorivo (lit.), električna energija (kWh), seme (kg), stajnjak (kg), đubrivo (kg), hemikalije (kg), mašine (h), ljudski rad i prinos (kg/ha). Ukupna energija se proračunava pomoću energetske ekvivalencije koji su već uneti u program. Razvijeni program uspešno računa potrošnju energije u MJ/ha. Program može da se pokaže kao koristan alat farmerima za predviđanje energetske potrebe u proizvodnji šećerne trske analizom sezonskih podataka.

Ključne reči: program, energetske potrebe, šećerna trska

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