The Andhra Agric. J 65 (1): 187-193, 2018

Energy usage and benefit -cost analysis of Cotton production in Guntur region of Andhra Pradesh

R Ravindra Raju and P Vidhu Kampurath

Department of Applied Engineering, Vignan's University –Vadlamudi, Guntur District, Andhra Pradesh.

ABSTRACT

The aim of this research is to determine the energy input and output involved in cotton production, considering one of the prominent cotton bowl of Guntur region of India. The average energy consumption of the farms investigated in this study is 18165 MJha^{-1}. Of the total energy, 11.71% is direct and 70.93% is indirect. Renewable energy accounts for 3.65% and Non-Renewable energy accounts for 78.9%, energy usage efficiency is 2.27. The total energy input into the production of one kilogram of average Indian cotton is estimated to be 5.1 MJ. The dominant contribution to input is energy in the form of nitrogen fertilizer (45.03%), followed by water for irrigation (17.34%) and diesel-oil (9.29%). The cost of cotton production per hectare is found to be 95000 Rs per ha in the region, with 80.0% of this being variable costs. It can be concluded that intensive cotton farms are being operated in the area since the variable cost ratio is quite high. With the benefit-cost ratio (1.44) analysis conducted, cotton production is found to be economically efficient for the region.

Key Words: *Cotton production in Guntur, energy in cotton, energy studies in cotton*

The introduction of high-yield varieties of major crops in the mid 1960s, paired with important technological changes, has led to an unprecedented rise in crop yield and land productivity in many parts of India. These new production technologies require a large quantity of input, such as fertilizers, irrigation water, diesel, plant protection chemicals, and electricity. The application of these inputs demands an increasingly higher use of energy from humans, animals and machinery.

The introduction of modern inputs changed the energy scenario of crop production. Therefore, it is imperative to analytically study the energy use patterns and predict what is likely to happen on the energy front.

Understanding energy usage in agricultural production is very important. The main problems facing energy usage are insufficient resources, high production costs, wrong resource allocation and increasing national and international competition in agricultural trade. Therefore, these limitations must be taken into consideration in order to implement sustainable agricultural production and self sufficient resource allocation in cotton production.

India has a very suitable ecologic and competitive potential for a number of agricultural products including cotton, Paddy, ground nuts, and chilies. As Singh (1997) indicated, the excessive and unconscious use of input in the production of cotton causes increasingly negative effects to both the environment and farmers. Thus, to increase energy usage efficiency, the input balance should be improved.

Cotton production in India is one of the major agricultural products. A total of 63750 kg of cotton was produced on115.53 lakh hectares in India in 2013-2014. Approximately 30-40 million people earn their livelihood from the cotton sector, and 6 million people engage in cotton production.

Energy output-input analysis is generally done to determine the scope of environment and energy efficiency of agricultural productions. A review on the energy content on cotton production as reported by various researchers is depicted in Table 1. The energy consumed was calculated based on 1 diesel (1 diesel = 56.31 MJ equivalence and is expressed in MJha-1) (Ozkan et al., 2004). The energy use values were calculated by multiplying the input and output components with their energy equivalents, as expressed in Table 1.

Guntur district, situated in the southern coast of India, is responsible for about 10% of the total Indian cotton production. Of the total land area available, 19.6% is engaged in cotton production every year. This research deals with the energy-use pattern for cotton cultivation in the Guntur region of India and calculates energy inputs and the efficiency of resource use.

MATERIAL AND METHODS

In this research, data were gathered from 120 cotton farmers using face-to-face interviews in the Guntur region of India. Mainly, socio-economic characteristics of the farms and input-output relations were included. A random sampling method was used. The sample size was calculated using the Neyman method (Yamane, 1967).

The permissible error in the sample size was defined to be 5% for a 95% confidence interval.

The socio-economic characteristics of cotton farmers are given in Table 2. From the data collected, the average farm size is 1.8 ha; cotton farming is found in 5.2 ha (80.00%) and other crops represent 1.3 ha (20%). The average household size was 5 persons. Farmers' age and experience in cotton production are 38.5 years and 14 years, respectively. Farmers' education is 8 years on an average, which is slightly higher than other agricultural producers (Table 2).

The agricultural practices used in cotton production in the research area are presented in Table 3. The land is tilled twice between June-July using a plough. After two rounds of thinning in June and July, the cotton seed is sown in July-August. An average of 9 $kgha^{-1}$ cotton seed is used. The main varieties of cotton seed used in the region are BT-Cotton. Cotton is irrigated by the flood irrigation method between September and October. Fertilizer is applied approximately 6-7 times within the July to December term.

Plant protection was found to start in September-October and an average of 8 times application of pesticide and herbicide was seen. On average, the cotton crop is hoed six times by hand during the period of December- February. The cotton is generally harvested by hand two times during December-January and four times during January - February, which is called the "first and second hand gathering". The following formulae were used to calculate production value, net return and benefit cost ratio.

Total production value = Cotton yield ($kgha^{-1}$) * Cotton price (Rs kg^{-1}) —(1)

Gross profit = Total production value (Rs ha^{-1}) – Total production costs (Rs ha^{-1}) —(2)

Productivity = Cotton yield (kg ha^{-1}) / Total production costs (Rs ha^{-1}) —(3)

Net return = Total production value ($Rsha^{-1}$) – Total production costs (Rs ha^{-1}) —(4)

Benefit/cost ratio = Total production value (Rs ha^{-1}) / Total production costs (Rs ha^{-1}) —(5)

RESULTS AND DISCUSSION

The inputs used in cotton production and their energy equivalents and energy ratios per hectare are presented in Table 4. The results revealed that 224 h (86.15%) of human labor and 36 h (13.84%) of machinery power were consumed. 64.63% percent of the total human labor consumed for Fertilizer applications, pest control and chemical application and for 35.7% was spent harvesting.

Energy used through diesel, fertilizer and human beings played a significant role in the cotton production. Based on the energy equivalents of the inputs and out-puts presented in the Table 1, the average total energy consumed was calculated as 18164 MJ per hectare. It was 49 740 $MJha^{-1}$in Antalya (Yilmaz at al., 2005), 7 200 -12 264 MJ ha^{-1} in Punjab (Manes and Sing, 2005), and 40 557 $MJha^{-1}$ in Tamil Nadu (Sing at al., 1997). These differences can be explained by the inefficiencies of energy input usage and cotton yield per hectare. In our study, the energy input of chemical fertilizer (64.63%) in cotton production represents the biggest share of the total energy inputs. Water for irrigation and diesel-oil inputs follow with 17.34% and 9.29%, respectively. The energy equivalence of these three inputs are 11755, 3150 and 1689 $MJha^{-1}$, in the same order. As can be seen from Table 4, seed, harvest, and insecticides, Herbicides, fungicides and seeds consumed 6.121% with energy input of1112MJ/ha, 4.75% with energy input of 864 MJ/Ha, 2.12% with energy input of 386MJ/Ha and 1.23% with energy input of 225MJ/Ha respectively. The output-input ratio is 2.27.

The indiscriminate uses of various inputs have resulted in prohibitive cost of production and deterioration in environ-mental and soil quality and economic situation of the farmers. Thus, there is a need to balance the use of energy inputs and to improve the energy productivity of cotton cultivation. This can be achieved through optimum

Table 1. Energy content of cotton production inputs and outputs.

Energy Parameter	Energy (MJ unit^{-1})	Reference
Human labour (h)	1.96	(Sing 2002, Sing and Chandra 2001, Mani at al. 2007)
Tractor 50 kW (h)	41.40	(Tsatsarelis 1993, Fluck 1985, Loewer at al. 1977)
Plough (h)	22.80	(Tsatsarelis 1993, Fluck 1985, Loewer at al. 1977)
Sprayer (h)	23.80	(Tsatsarelis 1993, Fluck 1985, Loewer at al. 1977)
Wagon (h)	71.30	(Tsatsarelis 1993, Fluck 1985, Loewer at al. 1977)
Pump (h)	2.40	(Tsatsarelis 1993, Fluck 1985, Loewer at al. 1977)
Fertilizers		(Tsatsarelis 1993, Fluck 1985, Loewer at al. 1977)
N (kg)	60.60	(Sing 2002, Sing and Chandra 2001, Mandal at al. 2002, Mani at al. 2007, Shrestha 1998)
P (kg)	11.10	(Sing 2002, Sing and Chandra 2001, Mandal at al. 2002 Mani at al. 2007, Shrestha 1998)
K (kg)	6.70	(Sing 2002, Sing and Chandra 2001, Mandal at al. 2002 Mani at al. 2007, Shrestha 1998)
Insecticides (kg)	278.00	(Hülsbergen at al. 2002, Dalgaard at al. 2001, Wells 2001, Meul at al. 2007)
Fungicides (kg)	276.00	(Hülsbergen at al. 2002, Dalgaard at al. 2001, Wells 2001, Meul at al. 2007)
Herbicides (kg)	288.00	(Hülsbergen at al. 2002)
Seed (kg)	25.00	(Sing 2002)
Diesel (L)	56.31	(Sing 2002, Sing and Chandra 2001, Mandal at al. 2002, Mani at al. 2007)
Water for irrigation (m^3)	0.63	(Yaldiz at al. 1993)
Cotton (kg)	11.80	(Sing 2002)

Table 2. Socio Economic characteristics of cotton farmers

S. No	Features	Means	Percentage (%)
1	Land (ha)	1.8	NA
2	Farmers' age	38.5	NA
3	Farmers' Average Education time (years)	8.0	NA
4	Farmers' experience in agriculture (years)	14.0	NA
5	Number of persons in family	5.0	NA
6	Farmers' education level (no.of persons)	49.0	100
	-Literate	7.0	14.2
	-Primary school	28.0	57.1
	-Middle school	8.0	16.3
	-High school	4.0	8.16
	-University	2.0	4.08

Table 3. Agricultural practices in cotton production in Guntur region

Agricultural practices	Periods/Frequency
Common varieties	BT-Cotton
Seed (kgha^{-1})	9
Land preparation	June - July (using cultivator)
Average number of tilling	2
Thinning	June-July
Average number of thinning	2
Sowing	July-August
Irrigation border period	September-October
Number of irrigation borders	1
Fertilization period	September-October
Average number of fertilization applications	6,7
Spraying period	September-October
Average number of spraying	8
Hoeing period	December-January
Average number of hoeing	6 times by hand hoeing.
Harvesting period	December-January

Table 4. Energy consumption and energy input-output relationship for cotton production

Input	Quantity per unitq area (ha)	Energy Equivalent (MJ unit-1)	Total energy equivalent (MJ)	Percentage of tatal energy input (%)
Human labour (h)	224	1.96	439.04	
-Land preparations	4	1.96	7.84	0.04
-Sowing	20	1.96	39.20	0.21
-Cultural practices	120	1.96	235.20	1.29
-Harvesting	80	1.96	156.80	0.85
Machinery (h)	36			
Tractor	3	41.4	124.20	0.68
Ploughing	3	22.8	68.40	0.37
Sprayer	30	23.8	714.00	3.93
Chemical Fertilizer (kg)				
-Nitrogen	135	60.6	8181.00	45.03
-Phosphorus	70	11.1	777.00	4.22
-Potassium	65	6.7	435.50	2.39
Seed (kg)	9	25	225.00	1.23
Chemicals (kg)				
-Insecticides	4	278	1112.00	6.12
-Fungicides	1.4	276	386.40	2.12
-Herbicides	3	288	864.00	4.75
Diesel-oil (l)	30	56.31	1689.30	9.29
Water for irrigation (m^{3}ha^{-1})	5000	0.63	3150.00	17.34
Total energy input (MJ ha^{-1})			18166.00	
Yield (kgha^{-1})	3500	11.8	41300.00	
Energy output-input ratio			2.27	
Specific energy (MJkg^{-1})			5.20	
Energy productivity (kgMJ^{-1})			2.27	
Production cost (Rsha^{-1})			136,500.00	
Net energy yield (MJha^{-1})			23134.00	

Table 5. Energy consumption under different modes of energy sources for cotton production.

Energy forms	$MJha^{-1}$	Percentage of total Energy input (%)	Inputs
Indirect energy	12886	70.9	Fertilizers, chemicals,
Renewable energy	664	3.65	Human, seeds
Non-renewable energy	14350	79.0	Diesel, electricity, chemicals, fertilisers, machinery

Table 6. Economic analysis of cotton production.

S. No	Cost items	Unit	Value
1	Variable costs	Rs/ha	76000.00
2	Fixed costs	Rs/ha	19000.00
3	Total production costs	Rs/ha	95000.00
4	Selling price	Kg/ha	39.00
5	Cotton yield	Kg/ha	3500.00
6	Total production value	Rs/ha	136500.00
7	Gross profit	Rs/ha	41500.00
8	Productivity	Kg/Rs	3.70
9	Net return	Rs/ha	41500.00
10	Benefit/cost ratio	-	1.44
11	Average family income	Average Area * Net return	74700.00
12	Income per person	Avg family income / no.of persons in family	14940.00

use of various energy inputs.

Production costs and returns are also given in Table 4. The results show that the cost per hectare of cotton production is Rs.95000. Cotton yield in the area under investigation is about 3500 $kgha^{-1}$. Specific energy was calculated by dividing the total energy input into the yield per hectare and was found to be 5.1 $MJkg^{-1}$. In other words, for each kilogram of cotton produced, about 5.1 MJ of energy is consumed. This energy consumption is three-and four- fold smaller than it was in Antalya and Punjab, respectively. Net energy equivalence was calculated by subtracting the total energy consumption from the energy equivalence of cotton yield and was estimated to be 23134$MJha^{-1}$.

T he forms of energy inputs used in cotton production are given in Table 5. Energy input is considered in two different forms; direct and indirect energy or renewable and non-renewable energy. As can be seen from the table, a total of $Mjha^{-1}$ energy was used. Of this energy, 12886 $MJha^{-1}$ (70.93%) was indirect; including fertilizer chemicals, machinery and seeds, and 2128 $MJha^{-1}$ (11.71%) was direct energy, including human labor, diesel-oil and electricity.

It is seen that cotton production in Guntur Region is more intensive. Excessive (unbounded) input usage causes either important environmental damage or waste of capital. The renewable energy (including human labor and seed energy) ratio is 3.65% with Energy of 664 $MJha^{-1}$. The non-renewable energy (including diesel, electricity, chemicals, and fertilizer and machinery energy) ratio is about 78.9% of total used energy with energy input of 14350 $MJha^{-1}$.

The high ratio of non-renewable energy in the total used energy inputs causes negative effects on the sustainability in agricultural production of small-scale farms. Cotton requires a high amount of capital and input. However, small-scale farms are characterized by insufficient capital and relatively cheap family labor. So, as the renewable energy ratio increases in the product inputs, farms feel more comfortable due to less dependence on farm outputs. Although there are important technological innovations in cotton production, the area and production quantity of cotton could not be increased as much in India as the technological changes. This could be explained by the situation mentioned above. In countries where agricultural production is based on family operations (small-scale farms), the renewable energy ratio is very important for production decisions, thus resulting in production sustainability.

Therefore, a reduction in the total non-renewable energy ratio, specifically in chemical and fertilizer usage would have positive effects on the sustainability of cotton production as well as other positive environmental effects.

An economic analysis of cotton production is given in Table 6. According to the table, cost of cotton production is about Rs.95000ha^{-1} (79.9% of the total is variable and 20.1% is fixed cost). Farmers produce 1.0 kg cottons per Rs.39. Net return is found to be Rs.41500 ha^{-1}. The average family income can be calculated by multiplying the cotton area and income per hectare and is found to beRs.74700, with income per person being about Rs.14940 $year^{-1}$. Compared to the national average income per person (approximately Rs.87748 in India), it is not enough to continue production. This is one of the main reasons while India switched to a net cotton importer from a net cotton exporter country in last 20 years.

In our study, the benefit-cost ratio of the cotton production was calculated by dividing the gross product value into the total production cost in order to determine economic efficiency. The benefit-cost ratio (B/C) is found to be 1.44, which is lower than the average ratio for Indian agriculture during 2014-2015.

CONCLUSIONS

In this study, an energy output-input analysis was performed for cotton production in the Guntur Region of India. Total energy consists of the sum of all energy components used in production. The total energy consumption of cotton production in Indian agriculture was found to be 18165 MJ per hectare. The results indicated that the level of fertilizer was one of the significant determinants of the total energy input, followed by diesel oil and irrigation. Energy use efficiency is 2.27.

The total indirect energy consumption represents 70.93% in cotton production, and 11.71% is direct energy. This indicates that there was a capital-intensive production system in the region. Therefore, to be able to ensure the sustainability of cotton production, farms should be encouraged to decrease their input usage level towards organic production. This approach should be taken until the optimum farm size is reached. In addition, environmental damages would decrease concurrently. In this research, net return was calculated as Rs.41500ha^{-1}. Productivity and B/C ratio is 3.7 and 1.44, respectively. As a result, farm size should be increased by decreasing population density on the land. The capital requirements of farm enterprisers should be overcome by input and credit subsidies. With the appropriate input and price policy applications, excessive water and chemicals usage must be intercepted. Agricultural advising should also be activated. Due to high production costs in India, the competitive strength of Indian cotton producers is low. Cotton production should be encouraged for self-sufficiency and entrance into European Union markets.

LITERATURE CITED

Cetin B and Vardar V A 2008 "An economic analysis of energy req. and input cost for tomato production in Turkey", Renewable Energy. 33(3): 428-433.

Dalgaard T, Halberg N and Porter J R 2001 A model for fossil energy use in Danish agriculture used to compare organic and conventional farming. Agric. Ecosyst. Environ. 87: 51- 65.

Fluck R C 1985 Energy sequestered in repairs and maintenance of agricultural machinery. Trans. ASAE. 28: 738-44.

Goktolga Z G, Gozener B and Karkacier O 2006 Energy use in peach production: Case of Tokat province. GOU. J. Agric. Faculty. 23(2): 39-44.Turkey.

Hulsbergen K J, Feil B and Diepenbrock W 2002 Rates of nitrogen application required to achieve maximum energy efficiency for various crops: results of a long-term experiment. Field Crops Res. 77: 61-76.

Mandal K G, Saha P, Ghosh K, Hati M and Bandyopadhyay K K 2002 Bioenergy and economic analysis of soybean based crop production systems in Central India. Biom. Bio energy. 23: 33-45.

Manes G S and Singh S 2005 Sustainability of cotton cultivation through optimal use of energy inputs in Punjab IE (I) J. AG. 86: 61-64.

Mani I, Kumar P, Panwar J S and Kant K 2007 Variation in energy consumption in production of wheat-maize with varying altitudes in Hilly Regions of Himachal Pradesh, India. Energy. 32: 2336-39.

Meul M, Nevens F, Reheul D and Hofman G 2007 Energy use efficiency of specialized dairy, arable and pig farms in Flanders. Agric. Ecosyst. Environ. 119: 135-44.

Ozkan B, Akcaoz H and Karadeniz C F 2004 Energy requirement and economic analysis of citrus production in Turkey. Energy Conversion Mgt. 45: 1812-30.

Ozkan B, Fert C and Karadeniz C F 2007 Energy and cost analysis for greenhouse and open field grape production. Energy. 32: 1500-04.

Ozkan B, Kurklu A and Akcaoz H 2003 An output–input energy analysis in greenhouse vegetable production: a case study for Antalya region of Turkey. Biom Bio energy 26: 189–195.

Ozturk H H, Ekinci K and Barut Z B 2006 Energy analysis of the tillage systems in second crop corn production. J. Sustainable Agric. 28(3): 25-37.

Shrestha D S 1998 Energy input-output and their cost analysis in Nepalese agriculture. http://www.public.iastate.edu/~dev/pdfdocs/Energy.PDF/

Singh J M 2002 On farm energy use pattern in different cropping systems in Haryana India, Master of Science Thesis (Unpublished), International Institute of Management University of Flensburg, Germany.

Singh R S and Chandra H 2001 Technological impact on energy consumption in rainfield soybean cultivation in Madhya Pradesh. Applied Energy. 70: 193-213.

Singh S, Verma S R and Mittal J P 1997 Energy requirements for production of major crops in India. Agric. Mech. Asia, Afr, Latin Am (AMA). 28(4): 13.

Tsatsarelis C A 1993 Energy inputs and outputs for soft winter wheat production in Greece. Agric. Ecosyst. Environ. 43: 10-18.

Wells D 2001 Total energy indicators of agricultural sustainability: dairy farming case study. Technical Paper 2001/3. Min. Agric. Forestry, Wellington, http://www.maf.govt.nz

Yaldiz O, Ozturk H H, Zeren Y and Bascetincelik A 1993 Energy use in field crops of Turkey. 5th International Congress of Agricultural Machinery and Energy, 12-14 October 1993, Kusadasý. Turkey.

Yamane T 1967 Elementary sampling theory. Prentice-Inc., Englewood. Cliffs, N. J., USA.

Yilmaz I, Akcaoz H and Ozkan B (2005). An analysis of energy use and input costs for cotton production in Turkey. Renewable Energy; 30: 145-55.

Received on 25.04.2017 and revised on 30.06.2017