African Journal of Agricultural Research Vol. 4 (7), pp. 599-604, July, 2009
Available online at http://www.academicjournals.org/AJAR
ISSN 1991-637X © 2009 Academic Journals

Full Length Research Paper

Energy usage and benefit-cost analysis of cotton production in Turkey

Erdal Dagistan[1]*, Handan Akcaoz[2], Bekir Demirtas[1] and Yalcin Yilmaz[3]

[1]University of Mustafa Kemal, Faculty of Agriculture, Department of Agricultural Economics, Hatay, Turkey.
[2]University of Akdeniz, Faculty of Agriculture, Department of Agricultural Economics, Antalya, Turkey.
[3]Vice-gavernor of Hatay Province, Hatay, Turkey.

Accepted 22 June, 2009

The aim of this research is to determine the energy input and output involved in cotton production in the Hatay province of Turkey. The average energy consumption of the farms investigated in this study is 19 558 MJha^{-1}. Of the total energy, 2.87% is direct and 71.13% is indirect. Renewable energy accounts for 12.30% and energy usage efficiency is found to be 2.36. The total energy input into the production of one kilogram of average Turkish cotton is estimated to be 4.99 MJ. The dominant contribution to input is energy in the form of nitrogen fertiliser (40.28%), followed by water for irrigation (22.37%) and diesel-oil (17.04%). The cost of cotton production per hectare is found to be 2 246 \$ha-^{1} in the region, with 79.87% 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. As a result of benefit-cost ratio (1.24) analysis, cotton production is found to be economically efficient.

Key words: Cotton, input-output analysis, energy analysis, production economics, Turkey.

INTRODUCTION

The introduction of high-yield varieties of major crops in the mid 1950s, paired with important technological changes, has led to an unprecedented rise in crop yield and land productivity in many parts of Turkey. These new production technologies require a large quantity of input, such as fertilisers, 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.

Turkey has a very suitable ecologic and competitive potential for a number of agricultural products including cotton, grapes, ground nuts, and apricots.

As Singh et al. (1997) indicated that 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 Turkey is one of the major agricultural products. A total of 899 000 tons of cotton was produced on 640,045 hectares in Turkey in 2006 (Anonymous, 2007).

Approximately 6 million people earn their livelihood from the cotton sector, and 1.5 million people engage in cotton production.

Turkey was a net cotton exporter up until 20 years ago. Currently, Turkey is a net cotton importer due to insufficient subsidies, a changing price party that is unfavourable to cotton selling prices and insufficient crop production.

In 1985, 155000 tons of cotton was exported without any import quantity. However, now only 49 000 tons of cotton are exported versus 697 000 tons imported. Turkey takes third place with a share of 6.22% of total world

*Corresponding author. E-mail: erdal@mku.edu.tr. Tel: +90 326 245 5845. fax: +90 326 245 5832.

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

Item	Energy Content (MJunit^{-1})	Reference
Human labour (h)	1.96	(Sing 2002, Sing and Chandra 2001, Mani at al. 2007)
Machinery		
Tractor 50 kW (h)	41.4	(Tsatsarelis 1993, Fluck 1985, Loewer at al. 1977)
Plough (h)	22.8	(Tsatsarelis 1993, Fluck 1985, Loewer at al. 1977)
Sprayer (h)	23.8	(Tsatsarelis 1993, Fluck 1985, Loewer at al. 1977)
Wagon (h)	71.3	(Tsatsarelis 1993, Fluck 1985, Loewer at al. 1977)
Pump (h)	2.4	(Tsatsarelis 1993, Fluck 1985, Loewer at al. 1977)
Fertilisers		(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)	11.1	(Sing 2002, Sing and Chandra 2001, Mandal at al. 2002 Mani at al. 2007, Shrestha 1998)
K (kg)	6.7	(Sing 2002, Sing and Chandra 2001, Mandal at al. 2002 Mani at al. 2007, Shrestha 1998)
Insecticides (kg)	278	(Hülsbergen at al. 2002, Dalgaard at al. 2001, Wells 2001, Meul at al. 2007)
Fungicides (kg)	276	(Hülsbergen at al. 2002, Dalgaard at al. 2001, Wells 2001, Meul at al. 2007)
Herbicides (kg)	288	(Hülsbergen at al. 2002)
Seed (kg)	25	(Sing 2002)
Diesel (1)	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)	11.8	(Sing 2002)

world cotton import quantity after China and Indonesia (Anonymous, 2004 and 2006). Cotton is mainly exported from the USA (61.3%), Greece (16.1%), Syria (6.9%) and Turkmenistan (4.5%). However, with regard to Turkey's cotton area and its production in the world, it is 7th and 5th, respectively.

Cotton production could not have increased as much as the need for cotton has increased. Increases in the cotton production of Turkey are due to increases in yield, not increases in the field in the last 20 years. Cotton production sustainability in Turkey is in danger as a result of the application of insufficient government policies, price policies, subsidies in favour of cotton instead of alternative crops (e.g., maize, canola), high input costs, small-scale farmers and insufficient capital existence.

Hatay province is found on the southern coast of Turkey. About 10% of the total Turkish cotton production area is in this province. In this region, 30% of the total land area is engaged in cotton production every year.

This paper deals with the energy-use pattern for cotton cultivation in the Hatay province of Turkey and calculates energy inputs and the efficiency of resource use.

Energy output-input analysis is generally done to determine the scope of environment and energy efficiency of agricultural productions. Detailed energy censuses and resource availability surveys have been conducted by Yilmaz et al. (2005) for the Central and Serik districts of Antalya (Southern Turkey), Ozkan et al. (2007) for greenhouse and open field grape production in Turkey, and Goktolga et al. (2006) for peach production in Turkey's Tokat province. Additionally, Cetin and Vardar (in press) analysed energy requirements and cost analysis in tomato production (South Marmara region of Turkey). Ozturk et al. (2006) also analysed the energy input and output in second crop corn production using four different tillage systems for soil preparation in the Cukurova region of Turkey. Gundogmus (2006) compared energy use in apricot production on organic and conventional farms in Turkey in terms of energy ratio, benefit/cost ratio and amount of renewable energy used.

MATERIALS AND METHODS

In this research, data were gathered from 54 cotton farmers using face-to-face interviews in the Hatay province of Turkey. 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.

Table 1 shows the energy equivalents of inputs and outputs of the cotton production. These coefficients were obtained from a number of different studies about relevant subjects. 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

Table 2. Socio economic characteristics of cotton farms.

Features	Means	(%)
Land (ha)	9.4	
Farmers' age	40.40	
Farmers' Average Education time (year)	7.27	
Farmers' experience in agriculture (year)	16.50	
Number of persons in family	4.30	
Farmers' education level (person)	54	100.0
-Literate	2	3.70
-Primary school	34	62.96
-Middle school	2	3.70
-High school	12	22.22
-University	4	7.41
Production System (ha)	9.38	100.00
-Cotton *(Gossipium hirsitum)*	7.53	80.27
-Other Crops	1.85	19.73

1. The study also benefited from previous research and studies about energy analysis in agriculture

RESULTS AND DISCUSSION

The socio-economic characteristics of cotton farms are given in Table 2. From the data collected, the average farm size is 9.38 ha; cotton farming is found in 7.53 ha (80.27%) and other crops represent 1.85 ha (19.73). The average household size is 4.30 persons. Farmers' age and experience in cotton production are 40.40 years and 16.50 years, respectively. Farmers' education is 7.27 years on 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 October-November using a plough. Then, after four rounds of thinning in February and March, the cotton seed is sown in March-April. An average of 33 kgha^{-1} cotton seed is used. The main varieties of cotton seed used in the region are Deltapine 15/21 and Çukurova 1518. Cotton is irrigated by the "wild irrigation method" about 4.5 times between June and August. Fertiliser is applied approximately 3.5 times within the March-July term.

Plant protection is started in April and ends August with an average pesticide and herbicide application of six. On average, the cotton crop is hoed two times by hand and four times by machine during the period of March-July. The cotton is generally harvested by hand two times during September and October, which is called the "first and second hand gathering".

The inputs used in cotton production and their energy equivalents and energy ratios per hectare are presented in Table 4. The results revealed that 535.7 h (97.30%) of human labour and 15.1 h (2.70%) of machinery power were consumed. Sixty-one percent of the total human labour for harvesting was spent on land preparation and other applications such as fertilization, pest control, and irrigation.

Energy used through diesel, fertiliser and human beings played a significant role in the cotton production. Based on the energy equivalents of the inputs and outputs presented in the Table 1, the average total energy consumed was calculated as 19 558 MJ per hectare. It was 49 740 MJha^{-1}in Antalya (Yilmaz at al., 2005), 7 200 -12 264 MJha^{-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 fertiliser (45.31%) in cotton production represents the biggest share of the total energy inputs. Water for irrigation and diesel-oil inputs follow with 22.37 and 17.04%, respecttively. The energy equivalence of these three inputs are 7 878, 4 374.7 and 3 333.6 MJha^{-1}, in the same order. As can be seen from Table 4, seed, harvest, and insecticides consumed 817.5 MJha^{-1}(4.18%), 640.90 MJha^{-1}(3.28%), and 556 MJha^{-1}(2.84%), respectively. The output-input ratio is 2.36 and is two times bigger than in the year 2000 (Ozkan at al., 2003). This is due to the rapid increase in the yield by irrigation with the South eastern Anatolian Project.

The indiscriminate uses of various inputs have resulted in a high cost of production and deterioration in environmental 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 use of various energy inputs.

Production costs and returns are also given in Table 4. The results shows that the cost per hectare of cotton production is 2 246$. Cotton yield in the area under investigation is about 3 917 kgha^{-1}. Specific energy was calculated by dividing the total energy input into the yield per hectare and was found to be 4.99 MJkg^{-1}. In other words, for each kilogram of cotton produced, about 4.99 MJ of energy is consumed. This energy consumption is three- and four- fold smaller than it was in Antalya and Punjap, respectively. Energy intensiveness was calculated by dividing total energy into the production cost and was found to be 8.71 MJha^{-1}. Net energy equivalence was calculated by subtracting the total energy consumption from the energy equivalence of cotton yield and was estimated to be 26 663 MJha^{-1}.

The 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 19 558 Mjha^{-1} energy was used. Of this energy, 15 183 Mjha^{-1} (71.13%) was indirect, including fertiliser chemicals, machinery and seeds, and 4 384 Mjha^{-1} (%28.87) was direct energy, including human labour, diesel-oil and electricity.

Table 3. Agricultural practices in cotton production in Hatay province.

Agricultural practices	Periods/Frequency
Common varieties	Deltapine 15/21, Çukurova 1518
Seed (kgha^{-1})	33
Land preparation	October-November (using plough)
Average tilling number	2
Thinning	February-March
Average number of thinning	4
Sowing	March-April
Irrigation border period	June-August
Number of irrigation borders	4.5
Fertilization period	March-July
Average number of fertilization applications	3,5
Spraying period	April-August
Average number of spraying	6
Hoeing period	March-July
Average number of hoeing	4 times by tractor and 2 times by hand
Harvesting period	September-October

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

	1	2	1*2	
Input	**Quantity per unit area (ha)**	**Energy Equivalent (MJunit^{-1})**	**Total energy equivalent (MJ)**	**Percentage of total energy input (%)**
Human labour (h)	53.7		1 050	5.37
-Land preparations	5.9	1.96	11.56	0.06
-Sowing	1.9	1.96	3.72	0.02
-Cultural practices	199	1.96	390.0	1.99
-Harvesting	327	1.96	640.9	3.28
-Other practices	1.9	1.96	3.72	0.02
Machinery (h)	15.1		308.0	1.58
-Land preparations	5.9	41.4	244.3	1.25
-Sowing	0.9	23.8	21.4	0.11
-Cultural practices	7.2	2.4	17.3	0.09
-Other practices	1.1	71.3	25.1	0.13
Chemical Fertiliser (kg)	240		8 861.4	45.31
-Nitrogen	130	60.6	7 878	40.28
-Phosphorus	56	11.1	621.6	3.18
-Potassium	54	6.7	361.8	1.85
Seed (kg)	32.7	25	817.5	4.18
Chemicals (kg)[a]	2.9		812.8	4.16
-Insecticides	2	278	556	2.84
-Fungicides	0.2	276	55.2	0.28
-Herbicides	0.7	288	201.6	1.03
Diesel-oil (l)	59.2	56.31	3 333.6	17.04
Water for irrigation (m3ha^{-1})	6 944	0.63	4 374.7	22.37
Total energy input (MJ ha^{-1})			19 558	100.00
Yield (kgha^{-1})	3 917	11.8	46 221	
Energy output-input ratio			2.36	
Specific energy (MJkg^{-1})			4.99	
Energy productivity (kgMJ^{-1})			0.20	
Production cost($ha^{-1})	2 246			
Energy intensiveness (MJ$$^{-1}$)			8.71	
Net energy yield (MJha^{-1})			26 663	

[a] Active ingredien

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

Energy forms	$MJha^{-1}$	Percentage of total energy input* (%)	Inputs
Direct energy	4 384	28.87	Human, diesel, electricity
Indirect energy	10 800	71.13	Fertilisers, chemicals, machinery, seeds
Renewable energy	1 867	12.30	Human, seeds
Non-renewable energy	13 316	87.70	Diesel, electricity, chemicals, fertilisers, machinery

*Energy equivalent of water for irrigation is not included.

Table 6. Economic analysis of cotton production.

Cost items	Unit	Value
Variable costs	$\$ha^{-1}$	1 777 (79.12)**
Fixed costs	$\$ha^{-1}$	469 (20.88)**
Total production costs	$\$ha^{-1}$	2 246 (100.00)**
Selling price	$kg\$^{-1}$	0.71
Cotton yield	$kgha^{-1}$	3 917
Total production value[a]	$\$ha^{-1}$	2 781
Gross profit[b]	$\$ha^{-1}$	535
Productivity[c]	$kg\$^{-1}$	1.74
Net return[d]	$\$ha^{-1}$	535
Benefit/cost ratio[e]	-	1.24

*1 US $ =1.30 New Turkish Liras (December, 2008).
** Numbers in parenthesis are the percentages of total costs in the production.
[a] Total production value = Cotton yield ($kgha^{-1}$) * Cotton price ($\$kg^{-1}$)
[b] Gross profit = Total production value ($\$ha^{-1}$) – Total production costs ($\$ha^{-1}$)
[c] Productivity = Cotton yield ($kgha^{-1}$) / Total production costs ($\$ha^{-1}$)
[d] Net return = Total production value ($\$ha^{-1}$) – Total production costs ($\$ha^{-1}$)
[e] Benefit/cost ratio = Total production value ($\$ha^{-1}$) / Total production costs ($\$ha^{-1}$)

The indirect energy ratio in cotton production is relatively high in Hatay province compared to Antalya (Yilmaz at al. 2005). This mean that cotton production in Hatay province is more intensive. Excessive (unbounded) input usage causes either important environmental da-mage or waste of capital.

The renewable energy (including human labour and seed energy) ratio is similar to that of the Antalya province (12.6 and 87.4%, respectively) (Yilmaz at al., 2005) at about 12.30%. The non-renewable energy (including diesel, electricity, chemicals, and fertiliser and machinery energy) ratio is about 87.70% of total used energy.

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. In particular, cotton requires a high amount of capital and input. However, small-scale farms are characterised by insufficient capital and relatively cheap family labour. 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 Turkey 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 fertiliser 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 2 246 $\$ha^{-1}$ (79.12% of the total is variable and 20.88% is fixed cost). Farmers produce 1.74 kg cottons per$. Net return is found to be 535 $\$ha^{-1}$. The average family income can be calculated by multiplying the cotton area and income per hectare and is found to be 4 012.5$, with income per person being about 933$ $year^{-1}$. Compared to the national average income per person (approximately 7 500$ in Turkey), it is not enough to continue production. This is one of the main reasons while Turkey switched to a net cotton importer from a net cotton exporter country within 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 1.24, which is slightly higher than the average ratio for Turkish agriculture (Ozkan at al., 2004).

Conclusions

In this study, an energy output-input analysis was performed for cotton production in the Hatay province of Turkey. Total energy consists of the sum of all energy components used in production.

In this study, total energy consumption of cotton production in Turkish agriculture was determined to be 19

558 MJ per hectare. The results indicated that the level of fertiliser was one of the significant determinants of the total energy input, followed by diesel oil and irrigation. Energy use efficiency is 2.36.

The total indirect energy consumption represents 71.13% in cotton production, and 28.87% is direct energy. This indicates that there was a capital intensive production system in the region. Thus, input usage is high and uncontrolled in Turkey. 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 535 $\$ha^{-1}$. Productivity and B/C ratio is 1.74 and 1.24, 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 subsidises. 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 Turkey, the competitive strength of Turkish cotton producers is low. Cotton production should be encouraged for self-sufficiency and entrance into European Union markets. Cotton sowing fields are becoming infertile due to excessive irrigation since cotton should not be irrigated more than three times. So, further research is needed to overcome these problems with tillage and irrigation systems.

ACKNOWLEDGEMENTS

Authors are grateful to the Akdeniz University for its support to the research.

REFERENCES

Anonymous (2007). Turkey’s statistical yearbook 2007. Turk. Stat. Instu. Pub. N0. 3144, Ankara, Turkey.

Anonymous (2006). Economic indicators of Turkish agriculture 2006. Agric. Econ. Res. Instu. ISBN: 975-407-213-2, AERI pres no: 150.

Anonymous (2004). Agean Exporters Union. Stuation of Turkish cotton sector towards to integration in the EU. Cotton Work Group Report., Izmir, Turkey, 23pp.

Çetin B, Vardar VA (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, Porter JR (2001). A model for fossil energy use in Danish agriculture used to compare organic and conventional farming. Agric. Ecosyst. Environ. 87: 51-65.

Singh RS, Chandra H (2001). Technological impact on energy consumption in rainfield soybean cultivation in Madhya Pradesh. Applied Energy. 70: 193-213.

Fluck RC (1985). Energy sequestered in repairs and maintenance of agricultural machinery. Trans. ASAE. 28: 738-44.

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

Gundogmus E (2006). Energy use on organic farming: a comparative analysis on organic versus conventional apricot production on small holdings in Turkey. Energy Conversion Mgt. 47: 3351-59.

Hülsbergen KJ, Feil B, Biermann S, Rathke GW, Kalk WD, Diepenbrock W (2001). A method of energy balancing in crop production and its application in a long-term fertilizer trial. Agric. Ecosyst. Environ. 86: 303-21.

Hülsbergen KJ, Feil B, 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.

Loewer OJ, Benock G, Gay N, Smith EM, Burgess S, Wells LG, Bridges TC, Springate L, Boling JA, Brattord G, Debertin D (1977). Production of beef with minimum grain and fossil energy inputs. Vol. I, II, III. Report to NSF.

Mandal KG, Saha KP, Ghosh PK, Hati KM, Bandyopadhyay KK (2002). Bioenergy and economic analysis of soybean based crop production systems in Central India. Biom. Bio energy. 23: 33-45.

Manes GS, 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 JS, 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, Hofman G (2007). Energy use efficiency of specialized dairy, arable and pig farms in Flanders. Agric. Ecosyst. Environ. 119: 135-44.

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

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

Ozkan B, Kurklu A, 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 HH, Ekinci K, Barut ZB (2006). Energy analysis of the tillage systems in second crop corn production. J. Sustainable Agric. 28(3): 25-37.

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

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

Singh JM (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.

Tsatsarelis CA (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 HH, Zeren Y, Bascetincelik A (1993). Energy use in field crops of Turkey. 5th International Congress of Agricultural Machinery and Energy, 12-14 October 1993, Kusadası. Turkey.

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

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