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**Short communication**

# Energy usage and economic analysis of cotton under various weed management practices

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The introduction of modern inputs changed the energy scenario of crop production. The main problems facing energy usage are insufficient resources, high production costs, wrong resource allocation and increasing national and international competition in agricultural trade. Agricultural energy requirements can be divided into direct and indirect energy requirements. The direct energy is related to crop production process as land preparation, irrigation, inter-culture, threshing, harvesting, and transportation of agricultural inputs and farm produce. Indirect energy needs are in the form of crop production inputs like seed, fertilizer and plant protection chemicals including biocontrol agents. Efficient use of these energies helps to achieve increased production and productivity and contributes to economy, profitability.

Agricultural practices in many developing countries continue to be based to a large extent on animal and human energy. Mechanical and electrical energy are available for agriculture insufficiently and hence the potential gains in agricultural productivity through the deployment of modern energy services are not being realized. The increase in area under high yielding varieties of various crops has put heavy demand on limited non-renewable energy sources. Renewable energy includes human labor, irrigation water, seeds and non-chemical fertilizers while non-renewable energy is consist of fossil fuels, pesticides, chemical fertilizers and machinery (Mohammadi *et al.* 2008). Cotton is a valuable product traded globally as well as an important employment creator. World widely, more than 100 million farming units are directly involved in cotton production, with many more in its complementary activities (FAO 2005). Major cotton producers and its international traders are China, India, USA, EU and Central Asian and African states. India has the credit of the largest area under cotton (126.55 lakh ha) and ranks second in cotton production (400 lakh bales) during 2014-15. However, the productivity of seed cotton in India is 537 kg/ ha which is below the world average of 790 kg/ ha.

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In Telangana, the cotton crop is being grown in an area of 16.51 lakh ha with the productivity of 515 kg/ha. This crop is mostly grown in alfisols of Southern Telangana agro climatic zone and black soils of Northern Telangana Zone. Since efficient use of the energy resources is vi-tal in terms of increasing production, productivity, competitiveness of agriculture as well as sustainability of rural living. Energy auditing is one of the most common approaches to examining energy efficiency and environmental impact of the production system. Estimating these functional forms is very useful for determining elasticity of inputs on yield and production (Hatirli *et al.* 2006).

Different energy efficiency parameters were determined to evaluate relationship between energy consumption and total output and production per hectare. Energy ratio, specific energy, energy productivity, energy intensiveness and net energy yield were calculated for cotton production under different weed management practices by following equations (Banaeian *et al.* 2010, Ghorbani *et al.* 2011).

Energy ratio = Energy output (MJ/ha)/Energy input (MJ/ha)

Specific energy = Energy input (MJ/ha)/Output (kg/ha)

Energy productivity = Output (kg/ha)/Energy input (MJ/ha)

Energy intensiveness = Energy input (MJ/ha)/Cost of production (Rs/ha)

Net energy yield = Energy output (MJ/ha) – Energy input (MJ/ha).

Energy use efficiency of different weed management practices was evaluated by the energy ratio between output and input. The energy input values for human labor, machinery, diesel fuel, fertilizers, pesticides and seed and the energy output value of cotton yield were used to estimate the energy ratio (Alam *et al.* 2005). Specific energy (MJ/kg) has been widely used in energy analysis to express the quantity of energy invested to produce unit quantity of the product. Energy productivity which measures the quantity of product produced per unit of input energy (kg/MJ) is the inverse of specific energy. This serves as an evaluator of how efficiently energy was utilized in the production system yielding a particular product. Based on the energy equivalents of inputs and output (Table 1) the above calculations were carried out based on experimental results of Bt cotton, conducted at college farm, Professor Jayashankar Telangana State Agricultural university, Rajendranagar during *Kharif* 2014 with 10 weed management practices, *viz.* pendimethalin at 1000 *fb* 2 HW at 20 and 50 DAS: pendimethalin at 1000 *fb* pyrithiobac-sodium at 62.5 g/ha: pendimethalin at 1000 *fb* pyrithiobac-sodium at 62.5 g/ha + quizalofop-p-ethyl at 50.0 g/ha, pyrithiobac-sodium at 62.5 g/ha+ quizalofop-p-ethyl at 50.0 g/ha, pyrithiobac-sodium at 62.5 g/ha + quizalofop-p-ethyl at 50.0 g/ha *fb* manual weeding at 50 DAS, pyrithiobac-sodium at 62.5 g/ha + quizalofop-p-ethyl at 50.0 g/ha *fb* directed spray of paraquat at 600 g/ha, pyrithiobac-sodium at 62.5 g/ha + quizalofop-p-ethyl at 50.0 g/ha *fb* directed spray of glyphosate at 2000g/ha, pendimethalin at 1000 g/ha *fb* glyphosate at 2000 g/ha directed spray, mechanical weeding thrice at 20,40 and 60 DAS and weedy check and replicated thrice.

**Analysis of input-output energy**

The results showed that about 1320 h human labor, 41.25 h machinery, 23.98 L diesel fuel, 270 kg chemical fertilizers (including 150 kg nitrogen, 60 kg phosphorus and 60 kg potassium) and 1.125 kg seed were used per hectare cotton production (Table 2). Amount of herbicide used in this study was varied from 0.475 kg to 4.8 kg depending upon the treatments used. Zahedi *et al.* (2014) reported that about 863 h human labor, 25 h machinery, 495 L diesel fuel, 237 kg chemical fertilizers (including 115 kg nitrogen, 69 kg phosphorus and 50 kg potassium) and 5200 kg farmyard manure were used per hectare cotton production in Turky.

In this study, total energy consumption of cotton production under various weed management practice varied in between 16051 MJ/ha to 19575 MJ/ha. Energy output-input ratio shows the efficiency of energy input and also marginal increase of output due to per unit increase in energy input. Higher energy use efficiency of 0.9 was observed with mechanical weeding thrice at 20, 40 and 60 DAS and was followed by pre-emergence application of pendimethalin at 1000 g/ha *fb* 2 HW at 20 and 50 DAS and early post emergence application of pyrithiobac-sodium at 62.5 g/ha + quizalofop-p-ethyl at 50.0 g/ha *fb* manual weeding at 50 DAS. This showed that cotton production under this treatment is not fairly efficient in terms of energy consumption as energy ratio of 2.36 (Dagistan *et al.* 2009) and 4.8 (Canakci *et al.* 2005) were also reported for cotton production.

**Table 1. Energy content of cotton production inputs and outputs and total energy equivalents per unit area**

| A. Inputs | Energy equivalent (MJ/ unit) | Quantity per unit area (ha) | Total energy equivalent (MJ) |
|---|---|---|---|
| 1.Human labour (h) | 1.96 | 165 | 2587 |
| 2.Machinery | | | |
| Tractor 50 kW (h) | 41.4 | 6.25 | 258.75 |
| Plough (h) | 22.8 | 20 | 456 |
| Sprayer (h) | 23.8 | 15 | 357 |
| Pump (h) | 2.4 | | |
| 3.Diesel (1) | 56.31 | 23.98 | 1350.31 |
| 4.Chemical fertilizers | | | |
| N (kg) | 60.60 | 150 | 9090 |
| P (kg) | 11.1 | 60 | 666 |
| K (kg) | 6.7 | 60 | 402 |
| 5. Chemicals | | | |
| Insecticides (kg) | 278 | 2 | 556 |
| Fungicides (kg) | 276 | | |
| Herbicides (kg) | 288 | | |
| 6.Electricity (kWh) | 11.93 | 24 | 286.32 |
| 7.Water for irrigation (m3) | 0.63 | 24 | 15.12 |
| 8. Seed (kg) | 25 | 1.125 | 28.12 |
| B. Outputs | | | |
| 1. Cotton seed yield (kg) | 11.8 | | |

Source: Dagistan *et al.* (2009)

Interms of specific energy, the lowest amount of energy of 12.9 MJ was invested to produce unit quantity of the seed cotton (kg) in mechanical weeding thrice treatment. This was reflected interms of higher productivity with production of 0.07 kg/MJ of energy with same treatment. The lowest energy intensiveness of 0.5 MJ per rupee was reported in pre emergence application of pendimethalin at 1000 *fb* 2 HW at 20 and 50 DAS as humon labour was engaged to remove the weeds. This treatment was followed by early post emergence application of pyrithiobac-sodium at 62.5 g/ha + quizalofop- p- ethyl at 50.0 g/ha *fb* manual weeding at 50 DAS. However negative net energy yield was obtained in all the treatments due to the less seed cotton yield. In similar way 27.2 MJ $-1, 19.2 MJ /kg, 0.1 kg MJ-1 and -15625.2 MJ ha-1, of energy intensiveness, specific energy, energy productivity and net energy was obtained from cotton production respectively under iran conditions (Zahedi *et al.* 2014)

The energy use efficiency, energy intensiveness, specific energy, energy productivity, net energy and of cotton production system were 0.9, 0.7 MJ/ Rs,

**Table 2. Energy input-output relationship for cotton production under various weed management practices**

| Treatment | Kapas yield kg/ha | CC `/ha | Energy out put (MJ/ha) | Total energy input (MJ/ha) | Energy ratio | Speciifc energy MJ/kg | Energy productivity kg /MJ | Energy intensiveness MJ/` | Net energy yield MJ /ha |
|---|---|---|---|---|---|---|---|---|---|
| Pendimethalin fb 2 HW | 1209 | 32840 | 14266 | 17718 | 0.8 | 14.6 | 0.06 | 0.5 | -3452 |
| Pendimethalin *fb* pyrithiobac-sodium | 535 | 27127 | 6313 | 17905 | 0.3 | 33.4 | 0.02 | 0.7 | -11592 |
| Pendimethalin *fb* pyrithiobac-sodium + quizalofop- p- ethyl | 637 | 27449 | 7516 | 18193 | 0.4 | 28.5 | 0.03 | 0.7 | -10677 |
| Pyrithiobac-sodium + quizalofop- p -ethyl | 583 | 25858 | 6879 | 17243 | 0.4 | 29.5 | 0.03 | 0.7 | -10364 |
| Pyrithiobac-sodium + quizalofop- p- ethyl *fb* manual weeding | 1019 | 29608 | 12024 | 17046 | 0.7 | 16.7 | 0.05 | 0.6 | -5022 |
| Pyrithiobac -sodium + quizalofop –p-ethyl *fb* directed spray of paraquat | 783 | 26758 | 9239 | 17963 | 0.5 | 22.9 | 0.04 | 0.7 | -8724 |
| Pyrithiobac-sodium + quizalofop –p- ethyl *fb* directed spray of glyphosate | 806 | 27809 | 9510 | 18625 | 0.5 | 23.1 | 0.04 | 0.7 | -9115 |
| Pendimethalin *fb* glyphosate directed spray | 828 | 27291 | 9770 | 19575 | 0.5 | 23.6 | 0.04 | 0.7 | -9805 |
| Mechanical weeding (3) | 1427 | 26750 | 16838 | 18550 | 0.9 | 12.9 | 0.07 | 0.7 | -1712 |
| Weedycheck | 200 | 23750 | 2360 | 16051 | 0.1 | 80 | 0.01 | 0.7 | -13691 |
| LSD (P=0.05) | 231 | | | | | | | | |

12.9 MJ/kg, 0.9 kg/MJ and -1712 MJ /ha respectively. The results indicate that cotton production under this treatment is not efficient enough in terms of energy consumption. Based on the analysis there is a need to increase the cotton output to get more net energy yield in order to increase the energy use efficiency of inputs.

## SUMMARY

The objective of energy usage and benefit-cost analysis of Bt cotton was to determine the energy efficiency indices under different weed management practices in Bt cotton. The field experiment was carried out at college farm, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad during *Kharif*, 2014 with ten weed management practices. The inputs in the calculation of energy usage in agro-ecosystems embraced labour, machinery, electricity, diesel oil, fertilizers, herbicides, pesticides, seeds, while seed cotton was included in the output. The results depicted that total input and output energy under different weed management practices were about 16051 to 18550 and 2360 to 16838 MJ/ha, respectively. Out of all the treatments tested the highest energy use efficiency (0.9), energy intensiveness (0.7 MJ/₹), specific energy (12.9 MJ / kg), energy productivity (0.9 kg/MJ), net energy (-1712 MJ/ha) of Bt cotton production system were reported in mechanical weeding thrice at 20, 40 and 60 DAS. However the lowest energy intensiveness of 0.5 MJ per rupee was reported in pre emergence application of pendimethalin at 1000 *fb* 2 HW at 20 and 50 DAS treatment.

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