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An Analysis of Energy Balance Studies on *Bt* Cotton Production under High Density Planting System in Telangana

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ABSTRACT: The assessment of the energy requirements of *Bt* cotton was carried out during *kharif* 2021-22 at College farm, PJTSAU, Rajendranagar, Hyderabad. The aim of this research is to determine the energy input and output involved in *Bt* cotton production. The average energy consumption of *Bt* cotton production investigated in this study was 18302 MJ ha^{-1}. The experiment was laid out in factorial RBD consisting of four levels of planting densities *viz.*, 90 × 15 cm, 90 × 20 cm, 90 × 30 cm and 90 × 60 cm as factor I treatments and 4 levels of nitrogen *viz.*, 90, 120, 150, 180 kg N ha^{-1} as factor II treatments and replicated thrice. Results depicted that among plant spacing, the total input and output energy of *Bt* cotton were about 17942 to 18680 and 81529 to 114707 MJ ha^{-1}, respectively. Significantly, higher net energy (96027 MJ kg^{-1}), energy ratio (6.17), energy productivity (0.117 kg MJ^{-1}) and lower specific energy (8.56 MJ kg^{-1}) was recorded with closer spacing of 90 × 15 cm and was at par with spacing 90 × 20 cm. Regarding nitrogen doses, the total input and output energy of *Bt* cotton ranged between 15430 to 21275 and 88543 to 106883 MJ ha^{-1}, respectively. Where, significantly higher net energy (86508 MJ kg^{-1}) was recorded with 150 kg N ha^{-1} and was comparable with application of 180 and 120 kg N ha^{-1}. While, significantly lower specific energy (8.95 MJ kg^{-1}) required to produce higher energy productivity (0.113 kgMJ^{-1}) and energy ratio (5.76 MJ kg^{-1}) were recorded with application of 120 kg N ha^{-1} and was on par with application of 90 and 150 kg N ha^{-1}.

Keywords: *Bt* cotton, Energy ratio, High density planting, Input energy use, Nitrogen.

INTRODUCTION

Energy is one of the most valued inputs in production agriculture and is a key factor in boosting crop yield for rapidly growing world population (Khan *et al.*, 2009). It is invested in various forms such as mechanical (human labour, farm machines, animal draft), electrical, chemical (fertilizer, pesticides, herbicides), etc. (Stout, 1990). Energy balance is defined as the quantifying proportion as well as analysis of the energy input consumed and output produced out of various activities to find out the direction of energy consumption pattern of a system (Acharya *et al.*, 2013). Energy analysis that suggests reducing inputs and increasing energy consumption. If an agricultural production generates more output (output energy) with less input energy(especially non-renewable inputs *viz.*, petrol, diesel, electricity, chemicals and fertilizers), it is said to be efficient. This makes the agricultural production system viable in environmental and economic terms (Sefeedpari *et al.*, 2012). In the developed countries, increase in the crop yields and land productivity were consequence of higher commercial energy inputs (technological changes) with improved crop varieties (Faidley, 1992). The introduction of modern inputs changed the energy scenario of crop production. The key problems concerning energy usage include a lack of resources, high production costs, inefficient resource allocation, and increasing domestic and global competitiveness in the agriculture trade (Rani *et al.*, 2016). Human labour is the most important source of energy in agriculture, though the introduction of machines has reduced human labour in the industry but, in the field activities, human labour is still playing its key role (Smil, 2008; Imran *et al.*, 2020).

Cotton as a fibre crop has a unique place in the Indian economy as it plays an important role in the agrarian and industrial activities of the nation. In India, cotton is being grown in an acreage of 12.09 million ha, while the total production is 362.18 lakh bales (6.16 Million Metric Tonnes) during cotton season 2021-22 *i.e.*, 23% of world cotton production of 1555 lakh bales (26.44 Million Metric Tonnes) (Anonymous, 2022). The cotton textiles industry is the second largest employer in India after agriculture, while also sustaining the livelihoods of an estimated 6.5 million cotton farmers (Anonymous, 2022). Cotton being a long duration, wide spaced and nutrient exhaustive crop. With the intensification of agriculture, the use of non-farm inputs such as fertilizes, insecticides, herbicides, fungicides and various other chemicals has been increased with the time. The requirement of the energy for these inputs is high. At present, with the increasing crude oil prices day by day which in turn increases the price of the external inputs. Thus, the cost of cultivation multiplies with the benefits being limited. Hence, the calculation of energy inputs and outputs is inevitable (Varsha *et al.*, 2020). Energy inputs and outputs are important factors affecting the energy efficiency and environmental impact of crop production (Rathke *et al.*, 2007). It is very useful to analyse crops in terms of energy and this should be done without impairing the yield of the crops. Excessive and unconscious input consumption in cotton cultivation has increasingly detrimental consequences for both the environment and farmers. As a result, in order to enhance energy use efficiency, the input balance should be improved (Dagistan *et al.*, 2009). To achieve these goals, solutions such as integrated nutrient management, diversified cropping sequences, conservation agriculture etc., have been proposed. So, a plan to focus on rational use of energy resources complements, allowing decrease in energy inputs, increasing energy efficiency and conserving energy for future generations without threatening the food supply, requires an extensive analysis of energy inputs and outputs as a result this study was conducted to ascertain the effects of different parameters of energy inputs on biomass production of *Bt* cotton in Telangana.

MATERIALS AND METHOD

The experiment was conducted at the College farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar (17^{o}19′N 78^{o}23′E at an altitude of 542.3 m above mean sea level), Hyderabad, Telangana during *kharif* 2021-22 and laid in factorial randomized block design with three replications. The experiment consists of 16 treatment combinations comprising four planting densities or spacings (D$_1$- 90 x 15 cm (74,074 plants ha^{-1}), D$_2$ - 90 × 20 cm (55,555 plants ha^{-1}), D$_3$ - 90 × 30 cm (37,037 plants ha^{-1}), D$_4$ - 90 × 60 cm (18,518 plants ha^{-1}) and four nitrogen doses (N$_1$ - 90 kg ha^{-1}, N$_2$ -120 kg ha^{-1}, N$_3$ - 150 kg ha^{-1}, N$_4$ - 180 kg ha^{-1}). The soils of the experimental site were light textured sandy loam with low in available N (197 kg ha^{-1}), medium in available P (21.8 kg ha^{-1}) and organic carbon content (0.52%), high in available K (361 kg ha^{-1}) and pH (7.5). The crop was sown using NCS 2778 BG II hybrid, which is suitable for ultra high density planting. Nitrogen was applied in the form of urea as per treatments in four equal splits at 20, 40, 60, 80 DAS along with recommended dose of potassium and entire quantity of phosphorus was applied basally. All agronomic practices were performed similarly to all the treatments for successful crop growth. Seed cotton yield was taken from the net plot in three pickings during the study.

In addition to the field experimentation, a complete inventory of all crop inputs *viz.*, fertilizers, fuels, human labour, seeds, plant protection chemicals and machinery power and outputs *viz.*, seed cotton yield and straw yield were recorded. Energy input in different treatments was computed by multiplying the input with the corresponding energy coefficients and summing up of all different energy efficiency parameters were calculated to assess the relationship between energy input and total output or production per hectare. Energy ratio (energy use efficiency, EUE), net energy, specific energy and energy productivity were calculated for *Bt* cotton under high density planting systems by following equations

Energy ratio

$$\text{EUE} = \frac{\text{Energy output (MJ ha}^{-1}\text{)}}{\text{Energy input (MJ ha}^{-1}\text{)}}$$

Net energy

Net energy (MJ ha^{-1}) = Energy output (MJ ha^{-1}) – Energy input (MJ ha^{-1})

Specific energy (MJ kg^{-1})

$$\text{Specific energy (MJ kg}^{-1}\text{)} = \frac{\text{Energy input (MJ ha}^{-1}\text{)}}{\text{Output (kg ha}^{-1}\text{)}}$$

Energy productivity (kg MJ^{-1})

$$\text{Energy productivity (kg MJ}^{-1}\text{)} = \frac{\text{Output (kg ha}^{-1}\text{)}}{\text{Energy input (MJ ha}^{-1}\text{)}}$$

Based on the energy equivalent values of inputs and outputs (Table 1) the above calculations were carried out using experimental results. The data collected were subjected to statistical analysis of variance (ANOVA) by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Performance of *Bt* cotton yields (Table 2) revealed that at closer spacing of 90 × 15 cm recorded significantly higher seed cotton yield and stalk yield (2176 and 5087 kg ha^{-1}, respectively) over 90 × 30 cm (1857 and 4249 kg ha^{-1}) and 90 × 60 cm spacing (1623 and 3564 kg ha^{-1}) but was found to be at par with 90 × 20 cm spacing (2052 and 4784 kg ha^{-1}). With closer spacing, there were more plants per unit area, which resulted in a higher yield. These results are in close conformity with Devi *et al.* (2018). Among the nitrogen doses, significantly higher seed cotton yield (2072 kg ha^{-1}) was observed with application of 150 kg N ha^{-1} and was at par with 180 kg N ha^{-1} and 120 kg N ha^{-1}. Where, significantly higher stalk yield (4762 kg ha^{-1}) was reported with application of 180 kg N ha^{-1} and was at par with application of 150 and 120 kg N ha^{-1}. Lower seed cotton yield and stalk yield (1706 and 3909 kg ha^{-1}, respectively) were recorded with application of 90 kg N ha^{-1}. There was linear increase in seed cotton yield from 90 to 150 kg N ha^{-1} and on further increase *i.e.*, 180 kg N ha^{-1} did not show any positive response on seed cotton yield but there is an increase in stalk yield up to 180 kg N ha^{-1}. This might be due to more nutrient availability for higher nitrogen dose treatment which resulted in vegetative growth and ultimately stalk yield.

The amount of input energy used to produce crops varies greatly. Presently, energy usage influences the productivity and profitability of agriculture. As a result of increased usage of agrochemicals inputs and fluxed with more productive cultivars, the crop yields increased continuously. Despite the fact that modern agricultural systems use a lot of energy and are quite productive, their sustainability is in doubt. This analysis is crucial in order to make the necessary advances for a more effective and environmentally friendly production system. Table 2 provides information on energy balance studies. Total energy consumption of *Bt* cotton under various plant spacings varied between 17942 MJ ha^{-1} to 18680 MJ ha^{-1}. Among nitrogen doses, significantly higher energy consumption (21275 MJ ha^{-1}) was registered with application of 180 kg N ha^{-1} followed by 150 kg N ha^{-1} (19327 MJ ha^{-1}) and 120 kg N ha^{-1} (17177 MJ ha^{-1}). Lower energy consumption (15430 MJ ha^{-1}) was recorded with 90 kg N ha^{-1}. This deviation in inputs among nitrogen doses was due to higher value of energy coefficient for nitrogen fertilizer. Whereas, total energy output in *Bt* cotton were significantly influenced by plant spacings and nitrogen doses. Significantly, higher energy output (114707 MJ ha^{-1}) was obtained with closer spacing of 90 × 15 cm which was on par with 90 × 20 cm (107939 MJ ha^{-1}) and followed by 90 × 30 cm spacing (96271 MJ ha^{-1}). Where, significantly lower energy output (81529 MJ ha^{-1}) was obtained with wider spacing of 90 × 60 cm. Among nitrogen doses, significantly higher energy output (106883 MJ ha^{-1}) was recorded with application of 180 kg N ha^{-1} over with application of 90 kg N ha^{-1} (88543 MJ ha^{-1}) and was comparable to 150 kg N ha^{-1} (105835 MJ ha^{-1}) and 120 kg N ha^{-1} (99184 MJ ha^{-1}). The increased energy output values were due to higher seed cotton yield and stalk yield obtained in treatments with closer spacing and higher nitrogen dose application.

Khan *et al*. (2009) observed that Indian farms have the potential to increase the yield by increasing the fertiliser inputs which will contribute to sustainability by boosting energy efficiency. From the energy studies significantly, higher EUE and net energy (6.17 and 96027 MJ ha^{-1}, respectively) was recorded with 90 × 15 cm spacing and was on par with 90 × 20 cm (5.88 and 89477 MJ ha^{-1}) followed by 90 × 30 cm spacing (5.34 and 78145 MJ ha^{-1}). Where, significantly lower EUE and net energy (4.58 and 63587 MJ ha^{-1}, respectively) was recorded with 90 × 60 spacing. Among nitrogen doses, application of 120 kg N ha^{-1} recorded significantly higher EUE (5.76) over 180 kg N ha^{-1} (5.02) but was on par with 90 kg N ha^{-1} (5.73) and 150 kg N ha^{-1} (5.47). Lower EUE was due to higher input energy associated with higher N fertilizer. Lewandowski and Schmidt (2006) stated that a fall in the energy ratio is caused by increased chemical N fertiliser use. Where, significantly higher net energy of 86508 MJ ha^{-1} was recorded with application of 150 kg N ha^{-1} and was equally effective with application of 180 kg N ha^{-1} (85608 MJ ha^{-1}) and 120 kg N ha^{-1} (82007 MJ ha^{-1}). Deike *et al.* (2008) observed that more net energy gain occurs at higher output energy values.

The lower amount of energy of 8.56 MJ was invested to turn out unit quantity of the seed cotton yield (kg) in 90 × 15 cm spacing in terms of specific energy. This gave out higher productivity with production of 0.117 kg MJ^{-1} of energy with same treatment but was on par with 90 × 20 cm spacing and followed by 90 × 30 cm spacing. Where, higher amount of specific energy (11.03 MJ kg^{-1}) was spent with spacing of 90 × 60 cm to produce lower productivity of 0.091 kg MJ^{-1} with the same treatment. Regarding nitrogen doses, significantly lower specific energy of 8.95 MJ kg^{-1} was spent with application of 120 kg N ha^{-1} to produce higher energy productivity of 0.113 kg MJ^{-1} and was on par with application of 90 and 150 kg N ha^{-1}. With application of higher nitrogen dose *i.e.*, 180 kg ha^{-1} utilised higher amount of energy (10.77 MJ kg^{-1}) and produced lower energy productivity of 0.094 kg MJ^{-1} among the nitrogen levels tested. The interaction effect of yield and energetics were found to be non- significant during the study.

Table 1: Energy equivalent values of agricultural inputs and outputs in present study.

Source of energy	Equivalent energy
Input	
1. Human labours (h)	
Adult man	1.96 MJ h^{-1}
Women	1.57 MJ h^{-1}
2. Machinery	
Tractor kW(h)	64.80 MJ h^{-1}
Power weeder (h)	4.75 MJ h^{-1}
Sprayer (h)	23.8 MJ h^{-1}
3. Chemical fertilizers	
N (kg)	60.60 MJ kg^{-1}
P_2O_5 (kg)	11.10 MJ kg^{-1}
K_2O (kg)	6.70 MJ kg^{-1}
4. Chemicals	
Insecticide (kg)	278 MJ kg^{-1}
Herbicide (kg)	288 MJ kg^{-1}
5. Irrigation	
Water (m^3)	1.02 m^3
Electricity (kW h)	11.93 kW h
Pump (h)	2.4 kW h
6. Diesel (l)	56.3MJ l^{-1}
7. Seed (kg)	25 MJ kg^{-1}
Output	
1. Seed cotton (kg)	11.80 MJ kg^{-1}
2. Stalk (kg)	17.50 MJ kg^{-1}

Source: Dagistan *et al*. (2009); Devasenapathy *et al.* (2009)

Table 2: Energetics of *Bt* cotton as influenced by varied plant spacings and nitrogen doses under HDPS.

Treatments	Seed Cotton Yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Energy input (MJ ha^{-1})	Energy output (MJ ha^{-1})	Net energy (MJ ha^{-1})	Energy ratio	Specific energy (MJ kg^{-1})	Energy productivity (kg MJ^{-1})
Planting spacings (S)								
$\mathbf{S_1}$ - 90 × 15 cm	2176	5087	18680	114707	96027	6.17	8.56	0.117
$\mathbf{S_2}$ -90 × 20 cm	2052	4784	18462	107939	89477	5.88	8.98	0.112
$\mathbf{S_3}$ - 90 × 30 cm	1857	4249	18125	96271	78145	5.34	9.75	0.103
$\mathbf{S_4}$ -90 × 60 cm	1623	3564	17942	81529	63587	4.58	11.03	0.091
SEm +	65	146	501	2745	2411	0.13	0.24	0.003
CD (P=0.05)	189	422	NS	7928	6963	0.37	0.70	0.008
Nitrogen doses (N)								
$\mathbf{N_1}$ - 90 kg ha^{-1}	1706	3909	15430	88543	73113	5.73	9.17	0.110
$\mathbf{N_2}$ - 120 kg ha^{-1}	1935	4363	17177	99184	82007	5.76	8.95	0.113
$\mathbf{N_3}$- 150 kg ha^{-1}	2072	4651	19327	105835	86508	5.47	9.43	0.107
$\mathbf{N_4}$- 180 kg ha^{-1}	1996	4762	21275	106883	85608	5.02	10.77	0.094
SEm +	65	146	501	2745	2411	0.13	0.24	0.003
CD (P=0.05)	189	422	1446	7928	6963	0.37	0.70	0.008
Interaction (DxN)								
SEm +	131	292	1001	5489	4821	0.26	0.49	0.005
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

CONCLUSION

The research was carried out to determine the impact of various energy characteristics on *Bt* cotton yields and observed that nitrogen fertilizer, diesel fuel and chemical used for herbicide control were found to be the most energy consuming among all other forms of input energy. In certain cases, over application of fertilizer has adverse implications on crop output. From this investigation, high density planting with closer spacing of 90 × 15 cm utilised lower amount of energy (8.56 MJ kg^{-1}) to produce higher energy ratio (6.17), net energy (96027 MJ kg^{-1}) and energy productivity (0.117 kg MJ^{-1}). While, with application of 120 kg N ha^{-1} consumed less amount of energy (8.95 MJ kg^{-1}) to produce higher energy ratio (5.76) and energy productivity (0.113 kg MJ^{-1}). Thus, indicating that high density planting is suitable crop under rainfed environment producing higher seed output, net energy yield, and eventually increased energy use efficiency of inputs.

FUTURE SCOPE

Studies on high density planting on soil moisture conservation, nutrient management, cultivars selection and farm mechanization are needed that may further upscale the productivity and profitability of cotton.

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Conflict of interest. None.

REFERENCES

Acharya, S. K., Bera, S. and Ahmad, G. (2013). Estimation of farm energy balances of small farm management: a social ecological and techno managerial analysis. *Journal of Crop and Weed*, *9*(2), 91-95.

Anonymous (2022). Cotton Industry and Exports-IBEF. India Brand Equity Foundation. Available from http://www.ibef.org.COCPC (2022). Committee on Cotton Production and Consumption(Available from http://texmin.nic.in)

Dagistan, E., Demirtas, B. and Yilmaz, Y. (2009). Energy usage and benefit-cost analysis of cotton production in Turkey. *African Journal of Agricultural Research*, *4*(7), 599-604.

Deike, S., Pallutt, B. and Christen, O. (2008). Investigations on the energy efficiency of organic and integrated farming with specific emphasis on pesticide use intensity. *European Journal of Agronomy*, *28*, 461-470.

Devasenapathy, P., Senthilkumar, G. and Shanmugam, P.M. (2009). Energy management in crop production. *Indian Journal of Agronomy*, *54*, 80-89.

Devi, B., Bharathi, S., Sree Rekha, M. and Jayalalitha, K. (2018). Performance of cotton under high density planting with varied spacing and levels of nitrogen. *The Andhra Agricultural Journal*, *65*(1), 49-52.

Faidley, L. W. (1992). Energy and agriculture. In: R.C. Fluck (Ed), Energy in Farm Production, Elsevier, Amsterdam, pp. 1–12.

Gomez, K. A. and Gomez, A. A. (1984). Statistical procedures for agriculture research. John Wiley and Sons Publishers, New York. pp. 357-423.

Imran, M., Ozçatalbaş, O. and Bashir, M. K. (2020). Estimation of energy efficiency and greenhouse gas emission of cotton crop in South Punjab, Pakistan. *Journal of the Saudi Society of Agricultural Sciences*, *19*(3), 216-224.

Khan, M. A., Khan, S. and Mushtaq, S. (2009). Energy and economic efficiency analysis of rice and cotton production in China. *Sarhad Journal of Agricultural*, *25*(2), 291-300.

Lewandowski, I. and Schmidt, U. (2006). Nitrogen, energy and land use efficiency of miscanthus, reed canary grass and triticale as determined by the boundary line approach. *Agriculture, Ecosystem & Environment*, *112*, 335-346.

Rani, P. L., Yakadri, M., Mahesh, N. and Bhatt, P. S. (2016). Energy usage and economic analysis of cotton under various weed management practices. *Indian Journal of Weed Science*, *48*(1), 99-101.

Sefeedpari, P., Rafiee, S., Komleh, S. H. P. and Ghahderijani, M. (2012). A source-wise and operation-wise energy use analysis for corn silage production, a case study of Tehranprovince, Iran. *International Journal of Sustainable Built Environment*, *1*, 158-166.

Smil, V. (2007). *Energy in nature and society: general energetics of complex systems*. MIT press.

Stout, B. A. (1990). Handbook of Energy for World Agric. Elsevier Appld. Sci. London.

Varsha, N., Pratibha, G., Madhavi, M. and Ramprakash, T. (2020). Energy Balance Studies of Weed Control Practices in Rainfed Cotton. *Indian Journal of Agricultural Research*, *54*(4), 489-494.

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