Tillage Practices and *Rabi* Crops Affects Energetics of Rainfed Rice Based Cropping System of Chhattisgarh

Abstract

In rice based cropping system, intensive tillage operations, which consume a huge amount of energy in the form of fuel and labor, are carried out after harvesting of rice for growing the next crop. Modification in tillage practices may not only reduce energy consumption but also could make the system more dynamic and efficient. The present study involving four tillage practices and six different *rabi* crops was undertaken in strip plot design with three replications to understand the effect of tillage practices and *rabi* crops on the energetics of rainfed rice based cropping system. Results of study clearly demonstrated that zero tillage direct drilling of seeds at 2nd days after harvesting of rice with toria and minimum tillage and line sowing of seeds at 3rd days after harvesting of rice with Safflower recorded 40% less energy input and 59% more energy output, respectively than Farmer's practice-seeds and fertilizers broadcasting at 12th days after harvesting of rice with Safflower. Among the tillage practices, zero tillage direct drilling of seeds at 2nd days after harvesting of rice recorded 63 and 74% higher energy productivity and energy intensity, respectively over farmers practice. Among the *rabi* crops, significantly higher energy productivity, energy intensity and net energy (0.84 kg MJ $^{-1}$, 6.74 MJ Rs $^{-1}$ and 66.72×10^{3} MJ ha^{-1}, respectively) were recorded under safflower. With higher energy productivity and intensity, ZT direct drilling of seeds at 2nd DAH of rice and safflower found best for the energetic management of rainfed rice based cropping system of Chhattisgarh.

Key words: Rabi crops. Tillage practices. Cropping system. Energy productivity. Energy intensity. Specific energy

Indian agriculture is traditionally a system of rainfed farming as about 53% area out of 139.9 million hectare (Mha) of net cropped area [1] is still rainfed, produces about 45% of food grains and 75-85% of pulses and oilseeds and a number of important industrial crops. Rice-based cropping systems is most dominant in the Chhattisgarh region of India and for sowing of *rabi* crops after harvesting of rainfed rice, intensive tillage operations, which consume large quantity of fuel and energy, are carried out to get desired seed bed for better seed germination and further crop growth. Adopting modified tillage practices not only reduce the cost of cultivation by reducing fuel consumption but also provide better conditions for growth and development of crop. Therefore, the zero tillage (ZT) and minimum tillage (MT) practices are considered as a viable alternative to conventional or intensive tillage [2] as ZT and MT remarkably reduce working time, fuel consumption, energy requirements and cost compared to conventional tillage (CT). In present scenario due to over exploitation of natural resources (soil, water and energy) and offset the production cost and environmental footprints, the conservation agriculture (CA) based crop production technologies are gaining attention to explore maximum yield potential of *rabi* crops [3]. The CA based crop management practices also found to be effective for increasing crop productivity [4, 5], profitability and energy use efficiency [6]. However, so for very few studies focusing on effects of tillage practices and *rabi* crops on energetics of rainfed rice based cropping system have been conducted across the globe. Therefore, looking into paucity of research data on enegetics of rainfed rice based cropping system, a study was undertaken to find out the effects of tillage practices and *rabi* crops on energetics of rainfed rice based cropping system of Chhattisgarh region.

A field experiment with 4 tillage practices (T_1-ZT direct drilling of seeds and fertilizers at 2^{nd} days after harvesting (DAH) of rice, T_2 -MT and line sowing of seeds at 3^{rd} DAH of rice, T_3-MT at 6^{th} DAH of rice, T_4-Farmer practice broadcasting seeds and fertilizer at 12^{th} DAH of rice in horizontal strips) and 6 different *rabi* crops (C_1-buckwheat, C_2-chickpea, C_3-lathyrus, C_4-safflower, C_5-linseed and C_6-toria in vertical strips) was undertaken at Research cum-Instructional Farm, Indira Gandhi Krishi Viswavidyalaya, Raipur, Chhattisgarh during *rabi* season of 2014-15 in strip plot design with three replications. Geographically, Raipur is situated in the centre of Chhattisgarh state and lies between 21^0 $16^{'}$ N latitude and 81^0 $36^{'}$ E longitudes with an altitude of 298 m above the mean sea level. The soil of the experimental field was sandy loam in texture (*Inceptisols*), had bulk density 1.48 g m^3, particle density 2.57 g m^3 and porosity 41%, pH 6.6, organic carbon 0.72%, available nitrogen 219 kg ha^{-1}, available phosphorus 16.70 kg ha^{-1}, exchangeable potassium 322.2 kg ha^{-1} and normal electrical conductivity. The crops varieties used for the experiment were JG-14 (Buckwheat), Prateek (Chickpea), Bhima (Safflower), RLC-92 (Lathyrus), Indira (Linseed) and Toria–1 (Toria). The sowing of different crop in treatment T_1, T_2, T_3 and T_4 was done on 31^{st} October, 1^{st}, 4^{th} and 10^{th} November 2014, respectively. All recommended package of practices of each crop were adopted during study period. The maximum and minimum temperature of study area during crop growing period varied between 25^0C to 37.3^0C and 8^0C to 21.5^0C, respectively with 3 to 9.8 per day bright sunshine hours. However, the maximum and minimum relative humidity in same period was recorded 94 and 22 per cent, respectively with 11.7 mm rainfall. The energy inputs were calculated in MJ ha^{-1} with reference to the standard values prescribed by Mittal et al. [7]. The other energy studies were done with the help of established equations are being mentioned as under:

Energy intensity (MJ Rs^{-1}) = Energy output (MJ ha^{-1})/ Cost of cultivation (1)

Energy productivity (kg MJ^{-1}) = Output grain + by product (kg ha^{-1})/ Energy input (MJ ha^{-1}) (2)

Specific energy = Energy input (MJ ha^{-1})/ Crop yield (kg ha^{-1}) (3)

Net energy = Energy output (MJ ha^{-1})- Energy input MJ ha^{-1} (4)

The data obtained under study were analyzed by the method of analysis of variance as described by Gomez and Gomez [8].

The highest energy input (6277 MJ ha^{-1}) was recorded under $T_4 \times C_4$ followed by 5945 MJ ha^{-1} under $T_4 \times C_1$. The lowest energy input (2572 MJ ha^{-1}) was recorded under $T_1 \times C_6$, which was 40% lesser than $T_4 \times C_4$ combination. These results are in agreement with the findings of Choudhary et al. [9], Khaledian et al. [10] and Jha et al. [11]. The significantly highest and lowest energy output was recorded under $T_2 \times C_4$ (86125 MJ ha^{-1}) and $T_4 \times C_6$ (22309 MJ ha^{-1}), respectively. These results are corroborated with the findings of Kumar et al. [12] and Singh et al. [13]. With respect to energy productivity and energy intensity, T_1 recorded significantly higher energy productivity (0.72 kg MJ^{-1}) and energy intensity (4.28 MJ Rs^{-1}), whereas, the lowest energy productivity (0.44 kg MJ^{-1}) and energy intensity (2.45 MJ Rs^{-1}) was recorded under treatment T_4. Mishra and Singh [14] observed higher energy productivity and energy intensity in ZT-ZT system due to higher system productivity. Yadav et al. [15] and Choudhary et al. [9] also noted the highest energy intensity under ZT sequence. Among the *rabi* crops, significantly higher energy productivity and energy intensity (0.84 kg MJ^{-1} and 6.74 MJ Rs^{-1}, respectively) was recorded under safflower. However, lowest energy productivity (0.34 kg MJ^{-1}) was recorded under the buckwheat. But, lowest energy intensity (2.29 MJ Rs^{-1}) was obtained under toria. Tillage practices and *rabi* crops also recorded significant difference (p=0.05) for net and specific energy. T_2 yielded significantly higher net energy (38.06×10^3 MJ ha^{-1}) over rest of the tillage practices but was at par with T_1. Whereas, the lowest net energy (25.97×10^3 MJ ha^{-1}) was recorded under T_4. Among the crops, significantly higher net energy (66.72×10^3 MJ ha^{-1}) and lowest net energy (19.29×10^3 MJ ha^{-1}) was recorded under safflower and buckwheat, respectively. With respect to specific energy, T_4 (858.82) and T_1 (544.08) respectively recorded significantly higher and lower specific energy. Significantly highest (1273.80) and lowest (344.35) specific energy among crops was recorded in buckwheat and lathyrus, respectively. Honnali and Chittapur [16] reported higher net energy returns in maize–chickpea followed by transplanted Bt cotton due more output energy and low input energy associated with these systems. Mishra et al. [17] also reported similar research findings.

Results of the study indicated that among the tillage practices, ZT direct drilling of seeds and fertilizers at 2nd DAH of rice followed by MT and line sowing of seeds at 3rd DAH of rice recorded maximum energy productivity, intensity, and net energy. However, among the *rabi* crops, Safflower adjudged better with respect to energy productivity, intensity, and net energy. Therefore, in conclusion, it may be said that ZT direct drilling of seeds at 2nd DAH of rice with safflower was best for the energetic management of rainfed rice based cropping system of Chhattisgarh. It is also suggested that further study of longer duration on similar line may be undertaken with the inclusion of some more *rabi* crops for getting better insights about energetics management in the rice based cropping system.

Acknowledgment

The authors are grateful to the Department of Agronomy, Indira Gandhi Agricultural University, Raipur for providing necessary facilities for completing the experiment.

References

1. Anonymous (2015-16) Annual report, Department of Agriculture and Cooperation, Ministry of Agriculture & Farmers' Welfare, GOI. pp 1

2. Dhar S, Das SK, Kumar S, Singh JB (2008) Effect of tillage and soil moisture conservation practices on crop yield of chickpea (*Cicer arietinum)* and soil properties under rainfed conditions. Indian J Agric Sci 78(12): 42-53

3. Saharawat YS, Ladha JK, Pathak H, Gathala M, Chaudhary N, Jat ML (2012) Simulation of resource-conserving technologies on productivity, income and greenhouse gas (GHG) emission in rice–wheat system. J Soil Sci Environ Managmt 3: 9–22

4. Jat ML, Gathala MK, Saharawat YS, Tetarwal JP, Gupta R, Singh Y (2013) Double no-till and permanent raised beds in maize–wheat rotation of north-western Indo Gangetic plains of India: effects on crop yields, water productivity, portability and soil physical properties. Field Crops Res 149: 291–299

5. Das TK, Bhattacharyya R, Sudhishri S et al (2014) Conservation agriculture in an irrigated cotton–wheat system of the western Indo-Gangetic Plains: Crop and water productivity and economic profitability. Field Crops Res 158: 24–33

6. Parihar CM, Jat SL, Singh AK, Jat ML (2011) Energy scenario and water and productivity of maize based cropping system under conservation agriculture practices in south Asia. In: Abstracts of 5th world congress on conservation agriculture, incorporating the 3rd farming system design conference held at Brisbane, Australia from 26th to 29th September: 144–150

7. Mittal NK, Mittal JP, Dhawn KC (1985) Research digest on energy requirement in agriculture sector (1971-82). ICAR/AICRP/ERA/85 (1), Ludhiana: 159-163

8. Gomez KA, Gomez AA (1984) Statistical procedures for agricultural research. A Willey-Inter Sci. Publication. John Willey & Sons, New York

9. Choudhary RL, Bahera UK (2013) Effect of sequential tillage practices and N levels on energy relations and use–efficiencies of irrigation water and N in maize (*Zea mays*)-wheat (*Triticum aestivum*) cropping system. Indian J Agron 58(1): 27-34

10. Khaledian M, Mailhol JC, Ruelle P (2012) Yield and energy requirement of durum wheat under no-tillage and conventional tillage in the Mediterranean Climate. J Bio Environ Sci 6(16): 59-65

11. Jha AK, Kewat ML, Upadhyay VB, Vishwakarma SK (2011) Effect of tillage and sowing methods on productivity, economics and energetic of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. Indian J Agron 56 (1): 35-40

12. Kumar B, Kerketta JK, Oraon PR (2016) Residual effect of tillage and nutrient management on production potential and energy budgeting of rice (*Oryza sativa*) under oat-rice cropping system. Int J Sci Environ and Tech 5(3): 1730–1734

13. Singh YP, Singh D, Tomar SS, Gupta RK (2013) Effect of time of pre-irrigation and tillage practices on wheat (*Triticum aestivum)* under pigeonpea (*Cajanus cajan*) - wheat cropping sequence. Indian J Agric Sci 83(12): 17–21

14. Mishra JS, Singh VP (2012) Tillage and weed control effects on productivity of a dry seeded rice–wheat system on *Vertisols* in Central India. Soil Till Res 123: 11-20

15. Yadav MR, Parihar CM, Jat SL et al (2016) Effect of long-term tillage and diversified crop rotations on nutrient uptake, profitability and energetic of maize (*Zea mays*) in north-western India. Indian J Agric Sci 86(6): 43–49

16. Honnali SN, Chittapur BM (2014) Efficient cropping systems and their energetics for sustainable irrigated tropical ecosystems. Indian J Agron 59(4): 556-560

17. Mishra MM, Mohanty M, Gulati JML, Nand SS (2013) Evaluation of various rice (*Oryza sativa*) based sequences for enhanced productivity, profitability and energy efficiency in eastern plateau and hills zone of India. Indian J Agric Sci 83(12): 79–84