



International Journal of Research in Agronomy

E-ISSN: 2618-0618

P-ISSN: 2618-060X

© Agronomy

www.agronomyjournals.com

2025; 8(1): 176-181

Received: 12-11-2024

Accepted: 15-12-2024

Siddharth Shankar Patre

Department of Agronomy,
Institute of Agriculture, Palli
Siksha Bhavana, Visva-Bharati,
Sriniketan, Birbhum, West Bengal,
India

Arun Kumar Barik

Department of Agronomy,
Institute of Agriculture, Palli
Siksha Bhavana, Visva-Bharati,
Sriniketan, Birbhum, West Bengal,
India

Soumita Chowdhury

Department of Agronomy,
Institute of Agriculture, Palli
Siksha Bhavana, Visva-Bharati,
Sriniketan, Birbhum, West Bengal,
India

Somnath Saha

Department of Agronomy,
Institute of Agriculture, Palli
Siksha Bhavana, Visva-Bharati,
Sriniketan, Birbhum, West Bengal,
India

Sk Naim Aktar

Department of Agronomy,
Institute of Agriculture, Palli
Siksha Bhavana, Visva-Bharati,
Sriniketan, Birbhum, West Bengal,
India

Corresponding Author:

Arun Kumar Barik

Department of Agronomy,
Institute of Agriculture, Palli
Siksha Bhavana, Visva-Bharati,
Sriniketan, Birbhum, West Bengal,
India

Energy efficiency of diversified winter baby corn-based cropping sequences in red and lateritic soil

Siddharth Shankar Patre, Arun Kumar Barik, Soumita Chowdhury, Somnath Saha and Sk Naim Aktar

DOI: <https://doi.org/10.33545/2618060X.2025.v8.i1c.2370>

Abstract

A field experiment was conducted during winter seasons of two consecutive years i.e., from the month November to January of 2021-22 and 2022-23 at Agricultural Farm, Palli Siksha Bhavana, Visva-Bharati, West Bengal with the aim to investigate the effect of energy efficiency of diversified winter baby corn-based cropping sequences in red and lateritic soil. The experiment was laid out in randomized block design with three replications having seven treatments (viz. T₁, baby corn-sesame; T₂, baby corn-green gram; T₃, baby corn-baby corn; T₄, baby corn-okra; T₅, baby corn-groundnut; T₆, baby corn-black gram and T₇, baby corn-vegetable cowpea). Experimental results revealed that similar energy inputs were used in both the years of experiments. Energy indices like energy output of grain yield, energy output of Stover yield, total output energy, net energy, energy output: input ratio, energy output efficiency, specific energy, energy productivity, energy intensity (in economic), were observed significantly highest with baby corn in baby corn-groundnut sequence over all other cropping sequences but was statistically at par with baby corn in baby corn-vegetable cowpea sequence. The lowest values were recorded with baby corn in baby corn-okra sequence. With respect to energy intensity in physical term, different baby corn-based cropping sequences did not differ significantly amongst themselves. However, superior energy intensity in physical term was also noted with baby corn in baby corn-groundnut sequence. So, inclusion of legumes (like groundnut and cowpea in baby corn based cropping sequences) was better proposition than inclusion of non-legumes in baby corn-based cropping sequences with respect to energetic assessment of crop diversification of winter baby corn-based cropping sequences in red and lateritic soil of West Bengal.

Keywords: Baby corn, energy indices, crop diversification, cropping sequences

1. Introduction

In Indian agriculture, the recently introduced crop, baby corn, holds particular relevance due to its applications as food, feed, and fodder, in addition to several industrial purposes (Kumar *et al.*, 2018). The varied applications of maize in the starch industry, oil production, baby corn, and popcorn, together with its export possibilities, have increased global demand for maize, in addition to other commercial opportunities. To enhance variety and value addition of maize, as well as to stimulate the food processing industry, the cultivation of maize for vegetable purposes, referred to as baby corn, is proposed. Baby corn is an immature, unfertilized, dehusked ear of maize, taken within 2-3 days post silk emergence. This short-duration crop, maturing in 60-70 days, can be sown and harvested 3-4 times annually (Bohra and Kumar 2015) [5]. Furthermore, baby corn, as a nutrient-depleting crop, exhibits a strong response to elevated fertility levels. The majority of its dietary requirements are satisfied through inorganic nutrient sources. Consequently, mono-planting of baby corn and inadequate nutrient management approaches will be unsustainable without a resource-efficient, diversified cropping system that incorporates integrated nutrient management. The intensification and replacement of crops in a baby corn-based cropping system would be a more effective approach to achieving sustainable production. Undoubtedly, cultivating baby corn as a monoculture is highly lucrative in the short term; but, diversity is important for sustainable production in the long term (Meena *et al.*, 2023). The incorporation of legumes into cereal-based farming systems has often been proposed as a strategy to enhance soil fertility and agro-ecological resilience for farmers with restricted access to nutrient resources (Yadav *et al.*, 2021) [25].

Inclusion of legume forage crops like fodder cowpea and lucerne improves the fertility status of soil by both efficient utilization of applied nutrients and addition of nitrogen to soil through root nodulation (Sharma *et al.*, 2009) ^[20]. The short duration pulse crops like cowpea and green gram could very well be introduced in food-forage based cropping systems during summer for maximizing the net returns and restoring the soil fertility (Kachroo *et al.*, 2014) ^[12]. The productivity and profitability of an intensive cropping system is possible only with sufficient number of irrigations. Energy consumption is a critical aspect of human existence and the national economy, with India requiring around 2 billion calories to sustain its rapidly growing population and produce over 200 million tons of food grain by 2000 (Mittal and Dhawan 1988) ^[17]. As energy costs rise, the population is becoming more aware of energy consumption. Historically, energy consumption in crop production has been insufficiently prioritized, necessitating a greater emphasis on renewable and non-commercial energy sources. Plants convert solar and chemical energy into storable chemical energy through photosynthesis, but excessive energy consumption leads to increased production costs, reduced net profitability, and reduced market competitiveness. To address this, cropping systems that enhance productivity and optimize energy conversion efficiency are essential. Incorporating crops like baby corn for diversification will diminish energy production due to their inefficiency in energy conversion. (Aghaalkhani *et al.*, 2013; Aktar *et al.*, 2024) ^[2, 3]. The efficient utilization of energy is crucial for improving productivity, profitability, and sustainability in agricultural production systems. The energy input-output relationship and productivity in agricultural production systems are contingent upon the sequence of crops cultivated, farm mechanization, tillage practices, application of organic manures and chemical fertilizers, pest management, crop harvesting and post-harvest processes, production levels, characteristics of farm produce, available resources, and soil quality (Kumar *et al.*, 2021) ^[13]. Energy requirements in agriculture are categorized into two groups: direct and indirect. Direct energy is essential for executing numerous tasks associated with crop production processes, including land preparation, irrigation, intercultural operations, threshing, harvesting, and the transportation of agricultural inputs and goods. Direct energy is utilized on farms and in the fields. Indirect energy comprises the energy utilized in the production, packaging, and transportation of fertilizers, pesticides, seeds, and agricultural machinery.

To promote more sustainable farming practices, energy consumption must be considered a fundamental metric. Agricultural production is significantly reliant on energy inputs, and the increasing usage of fossil fuel resources has raised concerns in both wealthy and developing nations (Vahedi 2020) ^[24]. Energy consumption in agriculture has escalated due to population growth, restricted arable land availability, and the demand for improved living standards (Hulmani *et al.*, 2022) ^[11]. It is essential to develop a production system that minimizes energy consumption while maximizing energy output in light of evolving global climate circumstances and rising energy needs

(Aakash Bhayal *et al.*, 2019) ^[1]. In this experiment, all inputs and outputs were regarded as energy. Human labor, animal power, fertilizers, gasoline, and electricity are utilized in various agricultural operations. All the inputs and the resulting output are regarded as energy. Power, electricity, machinery, seeds, fertilizers, and chemicals constitute a substantial segment of the energy supply within the current agricultural production system.

2. Materials and Methods

A field experiment was conducted at agricultural farm of Palli Shiksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, Birbhum, India during winter for the month November to January of 2021-22 and 2022-23. The experimental soil was acidic in reaction (pH 5.8), low in available nitrogen (157.9 kg ha⁻¹) and available phosphorus (14.68 kg ha⁻¹) and medium in available potassium (157.3 kg ha⁻¹) and experimental site lies in a sub-humid and semi-arid area of West Bengal situated at 23°66'N latitude, 87°65'E longitude with an altitude of 58.9 m from mean sea level.

The experimental site received total rainfall during crop period with 476.70 mm and 235.30 mm for 2021-22 (November to May) and 2022-23 (November to May), respectively. During 2021-22, highest temperature was recorded in April (40.63°C). where's during 2022-23 it was recorded in April (41.59°C). Lowest temperature during crop period for 2021-22 and 2022-23 was recorded in January. The experiment was conducted in a randomized block design with seven treatments (*viz.* T₁ baby corn-sesame, T₂ baby corn-green gram, T₃ baby corn-baby corn, T₄ baby corn-okra, T₅ baby corn-groundnut, T₆ baby corn-black gram and T₇ baby corn-vegetable cowpea) each with three replications. A total of 120 kg N, 60 kg P₂O₅ and 60 kg K₂O ha⁻¹ were applied to the baby corn. Total quantity of P₂O₅, K₂O and half quantity of total nitrogen was applied as basal dose during final land preparation and top dressing of the remaining half of nitrogen was done at the time of earthing up at 30 DAS (day after sowing). Sowing was done following all the recommended agronomic package of practices. The summer crops were raised as per recommended package of practices for each crop after harvest of baby corn as succeeding crops. With aim to calculate input-output ratios and other energy indices, the data were transformed into output and input energy levels using equivalent energy values for each commodity and input. Energy equivalents presented in Table 1. Initially, the quantity of inputs used in the production of winter baby corn were specified in order to calculate the energy equivalences in the study. Energy input includes human labour, water, chemical fertilizers, seed as well as output yield include corn and by product yield of baby corn. The total output, net energy, output input energy, output efficiency, specific energy, energy productivity, energy intensity in physical term, energy intensity in economic term were calculated according to following equations (Sheikh Davoodi and Houshyar, 2009 ^[21]; Taheri Garavand *et al.*, 2010 ^[22]; Moradi and Azarpour, 2011 ^[19]; Devasenapathy *et al.* 2009 ^[6]; Mittal and Dhawan 1988 ^[17]; Yadav *et al.* 2013 ^[26] and Babu *et al.* 2014 ^[4]).

Energy indices were calculated following standard method as mentioned below:

$$\text{Total output energy } \left(\frac{\text{MJ}}{\text{ha}} \right) = \text{Energy output by grain } \left(\frac{\text{MJ}}{\text{ha}} \right) + \text{Energy output by stover } \left(\frac{\text{MJ}}{\text{ha}} \right)$$

$$\text{Net energy gain } \left(\frac{\text{MJ}}{\text{ha}} \right) = \text{Total output energy } \left(\frac{\text{MJ}}{\text{ha}} \right) - \text{Total energy Input } \left(\frac{\text{MJ}}{\text{ha}} \right)$$

$$\text{Energy output: input ratio} = \frac{\text{Energy output by grain } (\frac{\text{MJ}}{\text{ha}})}{\text{Total energy Input } (\frac{\text{MJ}}{\text{ha}})}$$

$$\text{Energy output efficiency } \left(\frac{\text{MG}}{\text{days/ha}} \right) = \frac{\text{Energy output } (\frac{\text{MJ}}{\text{ha}})}{\text{Duration of crop (Days)}}$$

$$\text{Specific energy } \left(\frac{\text{kg}}{\text{MJ}} \right) = \frac{\text{Energy input } (\frac{\text{MJ}}{\text{ha}})}{\text{Crop yield } (\frac{\text{kg}}{\text{ha}})}$$

$$\text{Energy productivity } \left(\frac{\text{kg}}{\text{MJ}} \right) = \frac{\text{Grain yield } (\frac{\text{kg}}{\text{ha}})}{\text{Total energy input } (\frac{\text{MJ}}{\text{ha}})}$$

$$\text{Energy Intensity in economic term} = \frac{\text{Total energy output } (\frac{\text{MJ}}{\text{ha}})}{\text{Cost of cultivation } (\frac{\text{Rs}}{\text{ha}})}$$

$$\text{Energy Intensity in physical term} = \frac{\text{Total energy output } (\frac{\text{MJ}}{\text{ha}})}{\text{Grain yield } (\frac{\text{kg}}{\text{ha}})}$$

Table 1: Standard energy equivalent of agricultural input and output

Input	Unit	Equivalent energy (MJ)	Reference
Human Barbour (adult man)	Man-hour	1.96	Mittal <i>et al.</i> , 1985 ^[18]
Diesel	liter	56.3	Mittal <i>et al.</i> , 1985 ^[18]
Farm machinery			
Tractor(self-propelled)	kg	68.4	Mittal <i>et al.</i> , 1985 ^[18]
irrigation	m ⁻³	1.02	Tuti <i>et al.</i> , 2012 ^[23]
Chemical fertilizers			
a) N	kg N	60.6	Mittal <i>et al.</i> , 1985 ^[18]
b) P	kg P ₂ O ₅	11.1	Mittal <i>et al.</i> , 1985 ^[18]
c) K	kg K ₂ O	6.7	Mittal <i>et al.</i> , 1985 ^[18]
Manure/FYM	kg	0.3	Tuti <i>et al.</i> , 2012 ^[23]
Herbicides	Kg or l	238.3	Erdal <i>et al.</i> , 2007 ^[7]
Pesticide	kg	101.2	Erdal <i>et al.</i> , 2007 ^[7]
Fungicide	kg	181.9	Erdal <i>et al.</i> , 2007 ^[7]
Baby corn	kg	14.7	Mittal <i>et al.</i> , 1985 ^[18]
Out put			
Main product			
Baby corn	kg	1.6	Mittal <i>et al.</i> , 1985 ^[18]
By-product			
Stover	kg	12.5	Mittal <i>et al.</i> , 1985 ^[18]

Statistical analyses of the experimental data were done as described by Gomez and Gomez (1984)^[10] at 5% level of significance. Two years data were subjected to pooled analysis and the pooled data have been presented in tables.

3. Results and Discussion

During two consecutive years (2021-22 and 2022-23) of field experimentation on crop diversification in different baby corn-based cropping sequences, energy input, energy output by corn, energy output by byproduct, energy output, net energy output, energy output: input ratio, energy output efficiency, specific energy, energy productivity, energy intensity in economic terms, energy intensity in physical terms in baby corn were significant based on pooled data, except energy intensity in physical terms.

Energy parameters were calculated on the basics of energy equivalents of productivity of each crop and two years data were pooled which are presented in Table 2.

3.1 Energy input

With respect to energy input of baby corn, during two year of experiment, energy input in baby corn cultivation (13394.5 MJ ha⁻¹) was same in all baby corn based cropping sequences. This was mainly due to same package of practices and no increase in any input of baby corn cultivation during second year of experiment. (Table 2).

3.2 Energy output by baby corn Stover

Among various baby corn-based cropping sequences on pooled

data basis, (Table 2) baby corn in baby corn -groundnut sequence showed significantly highest energy output in corn and Stover yield (4516.1 and 352739.6 MJ ha⁻¹) over other cropping sequences and it was statistically at par with baby corn in baby corn-vegetable cowpea (4052.3 and 341054.2 MJ ha⁻¹) sequence. The lowest energy output in baby corn and strover yield was recorded in baby corn of baby corn - okra sequence (3157.7 and 305039.6 MJ ha⁻¹). The highest energy output with baby corn - groundnut sequence might be due to higher corn and strover yield and effect of nitrogen fixation of legume crop included in the sequence.

3.4 Total output energy

The data from pooled analysis on total output energy due to various baby corn-based cropping sequences differed significantly and revealed that highest total output energy was recorded with baby corn in baby corn -groundnut (357255.7 MJ ha⁻¹) and it was statistically at par with baby corn of baby corn-vegetable cowpea (345106.5 MJ ha⁻¹) sequence. The lowest total output energy was found in baby corn of baby corn - okra sequence (308197.3 MJ ha⁻¹). This might be due to higher corn and strover yield of baby corn (Table 2).

3.5 Net energy output

Among different baby corn-based cropping sequences, significantly highest net energy output was gained by baby corn in baby corn -groundnut (343861.2 MJ ha⁻¹) and it was statistically at par with baby corn-vegetable cowpea (331711.9 MJ ha⁻¹) sequence. The lowest net energy output was recorded with baby corn in baby corn - okra sequence (294802.8 MJ ha⁻¹). The higher net energy with baby corn-groundnut sequence might be attributed to less requirement of input energy for crop production while more output energy by corn and strover (Table 2).

3.6 Energy output: Input ratio

Results revealed that among baby corn-based cropping sequences, significantly highest energy output: input ratio was obtained with baby corn in baby corn -groundnut (26.7 ha⁻¹) and it was statistically at par with baby corn of baby corn-vegetable cowpea (25.8 MJ ha⁻¹) sequence. The lowest energy output; Input ratio was recorded in baby corn of baby corn - okra sequence (23.0 MJ ha⁻¹). The higher energy output; input ratio

with baby corn-groundnut sequences may be due to highest energy output by baby corn during crop production and less input energy having more output: input ratio (Table 2).

3.7 Energy output efficiency

The pooled analysis of energy output efficiency from various baby corn-based cropping sequences exhibited significant differences, indicating that highest energy output efficiency was observed in baby corn of baby corn-groundnut sequence (5214.0 MJ ha⁻¹ day⁻¹), which was statistically at par with baby corn in baby corn-vegetable cowpea sequence (5038.3 MJ ha⁻¹ day⁻¹). The lowest overall energy output efficiency was observed in baby corn of baby corn-okra sequence (4497.2 MJ ha⁻¹ day⁻¹). This was attributable to increased yields of corn and lowest crop duration of baby corn (Table 2).

3.8 Specific energy

In the analysis of diverse baby corn based cropping sequences, with respect to specific energy, significantly higher value was observed in baby corn of baby corn - okra sequence (6.9 MJ input kg⁻¹ yield) and least with baby corn of baby corn - groundnut sequence (4.8 MJ input kg⁻¹ yield) and it was statistically at par with baby corn of baby corn- green gram sequence (5.6 MJ input kg⁻¹ yield) and baby corn-vegetable cowpea sequence (5.3 MJ input kg⁻¹ yield). Lower the value of specific energy better was the system and vice versa. The superior specific energy from baby corn-groundnut sequence might be resulted from elevated yields of corn and Stover, attributable to the nitrogen fixation of leguminous crops, alongside minimal energy input in the cropping sequence.

3.9 Energy productivity

Various baby corn-based cropping sequences differed significantly on energy productivity on pooled data basis and revealed that highest energy productivity was recorded with baby corn in baby corn -groundnut (0.21 kg yield MJ⁻¹ input) and it was statistically at par with baby corn in baby corn-vegetable cowpea (0.19 kg yield MJ⁻¹ input) sequence. The lowest energy productivity was found with baby corn of baby corn-okra sequence (0.15 kg yield MJ⁻¹ input). This was due to higher corn and strover yield of baby corn and less energy input in systems (Table 2).

Table 2: Effect of different baby corn-based cropping sequences on energy indices of winter baby corn

Treatment	Energy input (MJ ha ⁻¹)	Energy output by Corn (MJ ha ⁻¹)	Energy output by Stover (MJ ha ⁻¹)	Total output energy (MJ ha ⁻¹)	Net energy output (MJ ha ⁻¹)	Energy output input ratio (MJ ha ⁻¹)	Energy output efficiency (MJ ha ⁻¹ day ⁻¹)	Specific energy (MJ input kg ⁻¹ yield)	Energy productivity (kg yield MJ ⁻¹ input)	Energy intensity (in economic) (MJ output rupee ⁻¹ invest)	Energy intensity in physical term (MJ kg ⁻¹)
	Mean	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
T ₁ -Baby corn-sesame	13394.5	3281.3	312625.6	315906.9	302512.4	23.6	4611.0	6.6	0.15	5.8	154.8
T ₂ -Baby corn-green gram	13394.5	3853.0	322577.1	326430.1	313035.6	24.4	4762.9	5.6	0.18	6.0	135.8
T ₃ -Baby corn-baby corn	13394.5	3358.2	318010.4	321368.7	307974.1	24.0	4689.7	6.4	0.16	5.9	153.8
T ₄ -Baby corn-okra	13394.5	3157.7	305039.6	308197.3	294802.8	23.0	4497.2	6.9	0.15	5.7	159.0
T ₅ -Baby corn-groundnut	13394.5	4516.1	352739.6	357255.7	343861.2	26.7	5214.0	4.8	0.21	6.6	126.1
T ₆ -Baby corn-black gram	13394.5	3605.6	320647.9	324253.5	310859.0	24.2	4730.4	6.0	0.17	6.0	143.4
T ₇ -Baby corn-vegetable cowpea	13394.5	4052.3	341054.2	345106.5	331711.9	25.8	5038.3	5.3	0.19	6.4	136.2
SE _{em} ±	-	193.6	9575.5	9639.77	9639.77	0.72	139.91	0.37	0.01	0.18	8.7
CD (P=0.05)	-	596.6	29504.9	29703.10	29703.10	2.22	431.11	1.13	0.03	0.55	NS

3.10 Energy intensity (in economic)

Among various baby corn-based cropping sequences baby corn in baby corn -groundnut sequence showed significantly highest energy intensity (in economic) (6.6 MJ output rupee⁻¹ invest) which was statistically at par with baby corn of baby corn-

vegetable cowpea energy intensity in economic terms (6.4 MJ output rupee⁻¹ invest) cropping sequence and the least energy intensity in economic terms (5.7 MJ output rupee⁻¹ invest) was observed in baby corn of baby corn -okra cropping sequence. This was because the lowest cost of cultivation and higher total

energy output in these sequences (Table 2).

3.11 Energy intensity (in physical) (MJ kg⁻¹)

Experimented data revealed that different baby corn-based cropping sequences did not differ significantly on pooled data basis. However superior energy intensity in physical term was noted with baby corn in baby corn-groundnut (126.1 MJ kg⁻¹) sequence. Lower the value of energy intensity in physical term better was the system and vice versa (Table 2).

Higher productivity of the crops in sequence might be attributed to better crop growth environment in terms of inclusion of leguminous crops in the system capable of fixing atmospheric nitrogen resulted in higher nutrient availability, better root growth, and modulation of micro climatic conditions with better water retention and higher productivity of the crops in sequence. Higher energy in this cropping system was due to higher crop yields in sequences. Similar findings were reported by Gangwar and Katyal (2001)^[8]. Mandal *et al.*, (2002)^[15] also mentioned that wheat grown in sequence after soybean or groundnut (*Arachis hypogaea* L.) produced higher bioenergy from grain and total biomass than after maize or rice in a sandy loam soil which was also in conformity with these findings.

4. Conclusion

Assessment of various energy indices throughout the cultivation of baby corn production various baby corn based cropping sequence highlighted that baby corn in baby corn-groundnut sequence performed best followed by baby corn-vegetable cowpea sequence and baby corn-green gram sequence. These findings supported the promotion and adoption of diversified winter baby corn-based cropping sequences in red and lateritic soil of West Bengal with respect to energetic assessment.

5. References

- Bhayal AL, Thakur NS, Kirar SK, Choudhary SK. Energetics of the maize production system as influenced by varieties and nitrogen scheduling. *J Exp Biol Agric Sci*. 2019;7(5):462-467.
- Aghaalkhani M, Poshtmasari KH, Habibzadeh F. Energy use pattern in rice production: a case study from Mazandaran province, Iran. *Energy Convers Manag*. 2013;69:157-162.
- Aktar SN, Pramanik K, Dhakre DS, Gupta RK, Patre SS. Energetic assessment of summer maize cultivation under nano zinc oxide and drip irrigation. *Int J Res Agron*. 2024;7(9):599-606.
- Babu S, Singh R, Avasthe RK, Yadav GS, Chettri TK. Production potential, economics and energetics of rice (*Oryza sativa*) genotypes under different methods of production in organic management conditions of Sikkim Himalayas. *Indian J Agron*. 2014;59(4):602-606.
- Bohra JS, Kumar R. Effect of crop establishment methods on productivity, profitability and energetics of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) system. *Indian J Agric Sci*. 2015;85(2):217-223.
- Devasenapathy P, Senthilkumar G, Shanmugam PM. Energy management in crop production. *Indian J Agron*. 2009;54(1):80-90.
- Erdal GK, Esengun H, Erdal G, Gunduz O. Energy use and economic analysis of sugar beet production in Tokat province of Turkey. *Energy*. 2007;32(1):35-41.
- Gangwar B, Katyal V. Productivity, stability and profitability of rice (*Oryza sativa*) based crop sequences in West Bengal and Orissa. *Indian J Agron*. 2001;46(3):46-3.
- Ghosh PK, Mohanty M, Bandyopadhyay KK, Painuli DK, Misra AK. Growth competition, yield advantage and economics in soybean/pigeon pea intercropping system in semi-arid tropics of India: Effect of sub-soiling. *Field Crops Res*. 2006;96:80-89.
- Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd Ed. New York: John Wiley & Sons, 1984.
- Hulmani S, Salakinkop SR, Somangouda G. Productivity, nutrient use efficiency, energetic, and economics of winter maize in South India. *PLOS ONE*. 2022;17(7):1-25.
- Kachroo D, Thakur NP, Kour M, Kumar P, Sharma R, Khajuria V. Diversification of rice (*Oryza sativa*) based cropping system for enhancing productivity and employment. *Indian J Agron*. 2014;59(1):21-25.
- Kumar A, Rana KS, Choudhary AK, Bana RS, Sharma VK, Prasad S, *et al.* Energy budgeting and carbon footprints of zero-tilled pigeonpea-wheat cropping system under sole or dual crop basis residue mulching and Zn-fertilization in a semi-arid agro-ecology. *Energy*. 2021;231(10):1-14.
- Kumar R, Bohra JS, Kumawat N, Upadhyay PK, Singh AK. Effect of balanced fertilization on production, quality, and energy use efficiency of baby corn (*Zea mays*) and soil health. *Indian J Agric Sci*. 2018;88(1):28-34.
- Mandal KG, Saha K, Ghosh PK, Hati K, Bandyopadhyay KK. Bioenergy and economic analysis of soybean-based crop production systems in central India. *Biomass Bioenergy*. 2002;23(5):337-45.
- Meena RP, Dhar S, Kumar A, Sathore SS, Singh VK, Bamboriya SD, Meena HR, Garg K, Kumar D, Meena MC. Productivity and profitability of baby corn (*Zea mays*)-based cropping systems under various nutrient-management practices. *Indian J Agron*. 2023;68(2):176-81.
- Mittal JP, Dhawan KC. Energy requirements in agricultural sector. Ludhiana: Punjab Agricultural University, 1988, p. 150.
- Mittal VK, Mittal JP, Dhawan KC. Research project on energy requirements in agriculture sector coordinating cell, Agricultural Engineering, PAU, Ludhiana, 1985, p. 62.
- Moradi M, Azarpour E. Evaluation of energy balance and energy indices of peanut production in north of Iran. *Afr J Agric Res*. 2011;6(4):381-384.
- Sharma AR, Behera UK. Nitrogen contribution through Sesbania green manure and dual-purpose legumes in maize-wheat cropping system: Agronomic and economic considerations. *Plant Soil*. 2009;325(1):289-304.
- Sheikh Davoodi MJ, Houshyar E. Energy consumption of canola and sunflower production in Iran. *Am Eurasian J Agric Environ Sci*. 2009;6(4):381-384.
- Taheri Garavand A, Asakereh A, Haghani K. Investigation of energy and economic analysis of soybean production in north of Iran. *Am Eurasian J Agric Environ Sci*. 2010;7(6):648-651.
- Tuti M, Mangal P, Prakash V, Pandey B, Bhattacharyya R, Mahanta D, *et al.* Energy budgeting of colocasia-based cropping systems in the Indian sub-Himalayas. *Energy*. 2012;45:986-993.
- Vahedi A. Energy analysis of three rice cultivars using different production methods: Case study Iran. *Agric Eng Int: CIGR J*. 2020;23(1):148-158.
- Yadav GS, Babu S, Das A, Datta M, Mohapatra KP, Singh R, *et al.* Productivity, soil health, and carbon management index of Indian Himalayan intensified maize-based cropping systems under live mulch-based conservation

- tillage practices. Field Crops Res. 2021;264:1-14.
26. Yadav SN, Chandra R, Khura TK, Chauhan NS. Energy input-output analysis and mechanization status for cultivation of rice and maize crops in Sikkim. Agric Eng Int: CIGR J. 2013;15(3):108-116.