Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.7021

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **6 (5):** 1162-1170 (2018)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Assessment of Energy Use and Productivity for Paddy Cultivation in North-Eaststate of India - Dimapur District of Nagaland

Liza G. Kiba[1], Bishorjit Ningthoujam[2*], Chitrasen Lairenjam[3], Sentirenal Pongen[4] and Neizevono Mor[5]

[1,3,4,5]Department of Agricultural Engineering and Technology, SETAM, Nagaland University, Dimapur – 797112, India

[2]Department of Agricultural Engineering, North Eastern Regional Institute of Science and Technology (NERIST), Nirjuli - 791109, Arunachal Pradesh, India

*Corresponding Author E-mail: bishorning@gmail.com

Received: 22.09.2018 | Revised: 20.10.2018 | Accepted: 27.10.2018

ABSTRACT

For sustainable agriculture practice, the efficient use of energy is necessary as it allows financial benefits to farmers. A study on assessment of energy used for rice cultivation was conducted at Department of Agricultural Engineering and Technology, SETAM, Nagaland University. The main objectiveof the study was to determine the total energy utilised, total productivity and energy productivity for rice cultivation in the four agricultural blocks in Dimapur district. It was found that the total energy utilized in Medziphema, Kuhuboto, Dhansiripar and Nuiland of Dimapur district were 1978.483 MJ/ha, 2589.782MJ/ha, 2042.195 MJ/ha and 2217.44 MJ/ha respectively. The direct input energy utilized were 1738.99 MJ/ha, 2208.886 MJ/ha, 1650.587 MJ/ha and 1894.77 MJ/ha and the energy from indirect sources were 239.823 MJ/ha, 380.8957 MJ/ha, 391.608 MJ/ha and 322.661 MJ/ha respectively in the four blocks. It was also obtained that the total productivityin four agricultural blocks of Dimapur district were 2521.135 kg/ha, 2448.50 kg/ha, 1500.81 kg/ha and 1645.696 kg/ha respectivelywith more efficient energy productivity of 1.27 kg/MJ in Medziphema block.

Key words: *Direct energy, Indirect energy, Energy productivity, Sustainable agriculture.*

INTRODUCTION

Agriculture may be defined as the production, processing, marketing and distribution of crops and livestock products.Agriculture alone accounts for about 34.8 percent of the national income and provides livelihood to 66.7 percent of the working population of the country[9]. Agriculture plays a crucial role in Indian economy and is known as thebackbone of our economy. Rice is one of the vital food crops in the world and India stand second in terms of area and production. In Asia, rice is the staple food for about 50 percent of the population, where 90 percent of the world's rice is grown and consumed[5]. Asia's food security depends largely on the irrigated rice fields, which account for more than 75 percent of the total rice production[16].

Cite this article: Kiba, L.G., Ningthoujam, B., Lairenjam, C., Pongen, S. and Mor, N., Assessment of Energy Use and Productivity for Paddy Cultivation in North-EastState of India - Dimapur District of Nagaland, *Int. J. Pure App. Biosci.* **6(5):** 1162-1170 (2018). doi: http://dx.doi.org/10.18782/2320-7051.7021

Copyright © Sept.-Oct., 2018; IJPAB

India is the world's largest producers of white and brown rice accounting for 20% of the whole world's rice production. It is also the staple food of the people of eastern and southern parts of the country with one of the largest areas under rice cultivation[8]. In India rice is cultivated in four broad production ecosystem (IRRI), Irrigated, Rain-fed Lowland, Upland and Flood prone respectively. Agriculture is the process of energy conversion, the conversion of solar energy into food, feed and fiber[13]. It is an established fact worldwide that agricultural production is positively correlated with energy input[12]. Bridges and Smith[2] developed a method for determining the total energy input for agricultural practices. Several studies have been done to quantify the energy consumption in agricultural production[4,14,15]. The study on energy use and output assessment of food-forage production systems[6].

The used of energy in agricultural production has become more intensive due to use of fossil fuels, chemical fertilizers, pesticides, machinery, electricity etc., however, it has also brought some outcomes in human health and environmental problems. Therefore, the efficient use of energy inputs has become important in terms of sustainable agricultural production[17]. The productivity and profitability of agriculture mainly depend on the energy consumption, direct and indirect energy. Direct energy is required for various operations like land preparation, irrigation, harvest, post-harvest processing, transportation of agricultural inputs and outputs.However, the indirect sources of energy are those which do not release energy directly but release it by conversion process. Also, some energy is invested in producing indirect sources of energy. Support indirect energy is in the form of seeds, manures, fertilizer, pesticide and machinery. The use of energy depends on mechanization level, quantity of active agricultural worker and cultivable land[10]. Efficient use of these energies helps to achieve increased production and productivity which eventually contributes to the profitability and competitiveness of agriculture sustainability in rural living[11]. Energy use in agriculture has been increasing in response to increasing population, limited supply of arable land and a desire for higher standards of living.

In North-Eastern region of India Nagaland lies in geographical coordinates of latitude 93°17´- 95°15´ East and longitude 25°10´- 27°01´North. Nagaland is divided into 11 administrative districts with 1 district in the plains and 10 districts in the hills. Nagaland covers an area of 16,579,00ha (0.5% of the India's geographical figure). The climate of Nagaland is tropical "monsoon" type with a hot wet summer and cool dry winter[3]. The state has an annual rainfall varies from 1000 mm in the Southwest to 6000mm in the North and temperature generally ranges from 0°C to 35°C.Agriculture is an important economic sector whereover 70 percent of the state's population is engaged in agriculture. Cultivation of rice is one of the major economic activities occupying about 70 percent of the total area and constitutes about 75 percent of the total food production.The total area under rice cultivation is 1,64,660 ha with a total production of 2,63,520 tonnes and average yield per hectare is estimated as 1.590 tonnes.Dimapur district has the highest area (35,080 ha) under rice cultivation[1].The three most important resources for agricultural productivity are land, water and energy. With the land being a fixed resource, water (rain or irrigation) and energy are the two resources which can be utilised rationally for enhancing the productivity. Use of the precious energy judiciously is an effective tool in enhancing crop productivity per unit area as agriculture has become very intensive. Determination of energy input for rice cultivation is essential for efficient energy allocation, use and to sustain its production growth in view of the growing energy crises. The present study was conducted to assessing the existing energy use pattern and resulting yield as a means to allocate energy input efficiently.

MATERIAL AND METHODS

2.1 Selection of study area and village resource assesment

The study area of Dimapur district has both plain area and hilly area, terraced and un terraced, so study area were selected to take care of these variations shown in Fig 1. Random sampling was done to select the farmers in each block to generate data through questionnaire. Detail information on farmer's land holding, different crops, number of labour hired, time required etc. was collected to study the energy utilization of Dimapur district. The general information of the district profile is shown in Table 1 below.

2.2 Data Collection

Data were collected from 44 farmers of 4 different agricultural blocks i.e. Medziphema, Dhansiripar, Kuhuboto and Nuiland of Dimapur district, 11 farmers from each block. The data were collected through questionaire on field observations and discussion with the farmers. These data includes land information such as the total land holding area, area under cultivation, input quantity of seed, fertilizer, chemical, farmyard manure and total production. Energy required in the form of human labour, animal or mechanical power for land preparation, levelling, secondary tillage, sowing, seedling uprooting, transplanting, weeding, spraying, harvesting, transporting and threshing were also recorded. After collecting preliminary information's related to their inventory and type of farming system, it was tried that maximum farmers were contacted to have required information in present Performa.

2.3 Details of the study area

The district comprises of four blocks and eleven agricultural circles. Medziphema block has a total area of 345 sq. Km with 67 revenue villages, Dhansiripar block has 130 sq. Km area with 28 revenue villages, Niuland block has 305 sq. Km with 59 revenue villages and Kuhuboto block has 137 sq. Km with 38 revenue villages. The plain sector consists of three blocks namely Dhansiripar, Niuland and Kuhuboto having identical topography, rainfall, type of soil and source of irrigation, whereas, the Medziphema block is at a higher altitude to that of the other three blocks.

Table 1: Details of district profile

Dimapur district profile at a glance	
Total geographic area	927 sq. Km (92700 ha)
Location	$25^0$48' & $26^0$00'North latitude and $93^0$30' & $93^0$54' east longitude
Number of villages	204
Number of households	28762
Population	308382
a) Male	166335
b) Female	142047
c) Male/female ratio	1.5:1
Density of population	332 per sq km
Literacy %	78.15%
a) Male	82.16%
b) Female	73.34
Climate	Subtropical
Temperature	10^0 - 40^0C
Soil pH	4.5 - 6.0
Rainfall	1500 - 2000 mm
Altitude	140 - 600 mt(ASL)
Major rivers	Dhansiri, Diphu, Chathe, Zubza

(Source: KVK, Dimapur. ICAR Research Complex for NEH region Nagaland Centre, Jharnapani.)

2.4 Source wise energy utilization

The source wise energy used in the selected crop cultivation is human energy, animal energy, mechanical energy, seed energy and fertilizer energy. Human energy is one of the most important sources of energy in various farm operations. Both male and female were engage in farm work. Animals such as bullocks and buffaloes in pairs are used for carrying out the field operation using plough and animal drawn implements. The mechanical energy was computed on the basis of total fuel consumption (litre/ha) in different operation. The values for the conversion factors are 1 man-hour=1.96 MJ, 1 woman-hour=1.57MJ, bullock pair-hour=10.10MJ, buffalo pair-hour=15.15MJ and 1 litre of diesel=56.31MJ respectively. The recommended seed rate used by the farmer was converted into seed energy using standard conversion factors i.e.1kg of dry mass of seed=14.7MJ. The nutrient requirements of various crops vary from one crop to another. The required amount of nitrogen, phosphorus, potash were then converted into energy (MJ) using standard conversion factor i.e. (1kg N_2=60.60MJ and 1kg P_2O_5=11.1 and K_2O=6.7MJ). The details of energy coefficients used in the study are given in Table 2.

Table 2: Energy coefficient used in energy calculation

Parameters	Unit	Equivalent energy, MJ
Human	Man-hour	1.96
Human	Woman-hour	1.56
Bullock	Pair-hour	10.10
Buffalo	Pair-hour	15.15
Diesel	Litre	56.31
Farm machinery excluding Self-propelled machines	Kg	62.70
Electrical motors	Kg	64.80
Prime movers other than electrical motors	Kg	64.40
FYM	Kg	0.3
Spray chemical(superior)	Kg	120
Spray chemical(inferior)	Kg	10.0
Seed (paddy)	Kg	14.7

(Source: Mittal V.K., Mittal T.K. and Dhawan K.C. 1985. Research digests on energy requirement in agricultural sector.)

2.5 Operation wise energy utilization

The energy requirement for various operations for rice cultivation varies considerably from one another. The major operations include land preparation, tillage operation, nursery rising, planting/transplanting/sowing, fertilizer application, pesticide/insecticide application, weeding, harvesting and threshing. Tractor/power tiller and animal power both were used for land preparation and average tractor size used ranges from 35-50 hp with fuel consumption ranges from 4-6 litre per hour. Both tractor and animal are involved in tillage operation whereas in hilly region, power tiller are used for tillage operation. Generally, tractor is operated for 8 hour/day per hectare for 5-6 times and human power involved is around 28 man-days per hectare. For nursery raising only human energy is involved and generally 6-7 man-days per hectare is required for nursery rising. For planting human energy equivalent to 50 man days per hectare and transplanting involves 40 man-days per hectare. The energy use per hectare for fertilizer and insecticide or pesticides application was 3 man-days per hectare. Weeding and harvesting operation was done manually and energy requirement per hectare is 35man-days and 40-50 man-days.

2.6 Calculation of Energy

The energy required for the farm operation was determined by calculating the total energy input which includes energy from bullock, machinery and human. Human energy is one of the most important sources of energy in various farm operations. The energy from direct sources comprises of the energy utilized during land preparation, tillage, sowing, transplanting and spraying

2.6.1 Energy from Direct Sources

Direct energy sources were labor energy, tractor and/or other implement/machinery used for the particular operation and electric/diesel motor to run water pump, while indirect energy sources included high yielding seed varieties, fertilizers and chemicals used in the production process.

DE= HLH ×1.96+BPH ×10.10+FC × 56.31+EC ×11.93

Where,

DE = Direct Energy, (MJ)

HLH = Human labour hours used, (h)

BPH = Bullock pair hours used, (h)

FC = Fuel consumption, (l)

EC = Electricity consumption (KWh)

2.6.2 Energy from indirect sources

IE= (C × WM × HUM × OA) +FYM × 0.3MJ/Kg +S × 14.7MJ/kg + Ch. × 120MJ/l × fertilizer (N × 60.0 ×P ×11.1 × K × 6.7)

Where,

IE = indirect energy input from machinery, (MJ)

C = energy coefficient, (MJ/kg)

WM =Weight of machinery used per hour, (kg)

HUM = hours use of machinery, (h)

OA = operational area (ha)

FYM = farm yard manure (kg/ha)

S = Seed, (kg/ha)

2.6.3 Total Energy

TE=DE+IE

Where,

DE =Direct Energy, MJ

IE =Indirect Energy, MJ

Based on the energy input and productivity the following was calculated:

Energy Productivity = Rice output (kg/ha)/Input energy (MJ)

RESULTS AND DISCUSSION

3.1 Direct and Indirect Energy Utilization between blocks of Dimapur

In Medziphema block wetland terrace paddy cultivation were practiced by both men and women and main sources of power are animal. The use of chemicals and fertilizers in this block was minimal, small canals were used for source of irrigation andmajority of the farmers are medium land holdings with 63.63%. The total direct energy utilization for different operation in rice cultivation was found to be 1738.66 MJ/ha shown in Table 3 and graphical representation of direct energy utilization is shown in Fig 1 below.. The farmer wise indirect energy utilization for each block is shown in Table 4. It was found that the total utilization for Medziphema block is 1978.483 MJ/ha.

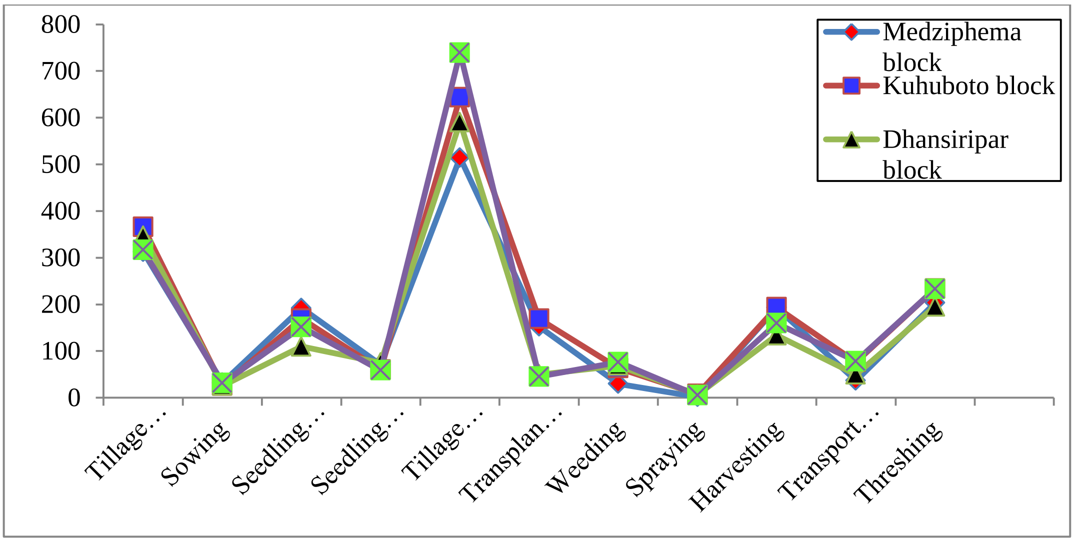

Fig. 1: Direct energy utilization for different operation in the 4 agriculturalblocks

Kuhuboto block followed the practices of lowland rain-fed cultivation. Bullock was used as a source for animate power and irrigation was fully dependent upon monsoon rains with maximum used of chemicals and fertilizers. The total direct and indirect energy utilised for this block was found to be 2208.886 MJ/ha and 380.896 MJ/ha. It was found that the total energy utilization for Kuhuboto block was 2587.782 MJ/ha. Dhansiriparand Niulandblock also practices lowland rain-fed cultivation. Here the farmers followed transplanting method and direct sowing method of the seeds; however, direct sowing of seeds was more common. Bullock was used as a source for animate power and irrigation for the fields was fully dependent upon monsoon rains with moderate used of chemicals and fertilizers. The total direct and indirect energy utilised for this block was found to be 1650.587 MJ/ha and 391.609 MJ/ha. It was found that the total energy utilization for Dhansiripar block was 2042.195 MJ/ha. It was also found that the total direct energy utilization in Niuland block was found to be 1894.777 MJ/ha. The used of Indirect energy from fertilizers, chemicals and seeds were found to be 322.661 MJ/ha with the total energy utilization of 2217.44 MJ/ha.

Table 3: Direct Energy Utilization in various Operation for Rice Cultivation for 4 different blocks (MJ/ha)

Blocks	Direct Energy Utilization in various Operation for Rice Cultivation between blocks (MJ/ha)											
	Tillage (Nursery)	Sowing	Seedling Uprooting	Seedling Transportation	Tillage (Main Field)	Transplanting/ Sowing	Weeding	Spraying	Harvesting	Transportation	Threshing	Total Energy (Direct) MJ/ha.
Medziphema	312.567	32.126	191.976	70.73	514.26	152.623	29.823	1.728	192.83	36.69	203.29	**1738.66**
Kuhuboto	366.255	25.637	169.315	59.983	644.07	169.03	63.267	7.699	193.678	76.56	233.39	**2208.886**
Dhansiripar	346.82	25.597	109.7	74.938	590.473	49.74	68.827	6.204	133.505	49.788	195.25	**1650.587**
Niuland	316.869	31.05	151.634	58.507	739.39	45.301	76.167	5.012	159.375	78.212	233.26	**1894.777**

Table 4: Farmer wise indirect energy utilization infour different blocks (MJ/ha)

Sl. No of farmer	Medziphema Block						
	Area (ha)	Seed rate	Seed Energy (Seed rate × 14.7)	Energy superior	Energy inferior	FYM	Total (MJ/ha.)
F1	2.14	12.86	189.10	55.97			245.07
F2	2.41	14.47	212.73				212.73
F3	2.01	12.06	177.28				177.28
F4	2.68	16.08	236.37				236.37
F5	3.35	20.1	295.47	7.16	59.70		362.33
F6	1.74	10.45	153.64	34.44			188.08
F7	3.35	20.1	295.47	5.97	24.87		326.31
F8	4.02	24.12	354.56	55.97			410.53
F9	1.07	6.43	94.55	11.85			106.40
F10	3.21	19.29	283.6				283.65
F11	1.01	6.07	89.25				89.25
Kuhuboto Block							
F12	3.48	20.90	307.28	20.66	28.70		356.65
F13	2.41	14.47	212.73	49.75	45.20		307.69

F14	1.87	11.25	165.46	51.17	53.30		269.93
F15	2.81	16.88	248.19	17.05			265.25
F16	1.60	9.64	141.82	44.77	62.18		248.79
F17	8.04	48.24	709.12		12.43		721.56
F18	3.48	20.90	307.28	55.10	57.40		419.80
F19	6.43	38.59	567.30	65.29	15.54		648.14
F20	5.36	32.16	472.75	22.38	27.96		523.10
F21	1.34	8.04	118.18	62.68	37.31	17.91	236.09
F22	3.48	4.82	307.28	20.66	62.18		192.80
Dhansiripar Block							
F23	5.36	53.6	787.92	33.58			821.50
F24	3.75	37.52	551.54	25.58		6.99	584.12
F25	2.14	21.44	315.16	33.58			348.75
F26	1.60	16.08	236.37	29.85	62.18	15.35	343.76
F27	1.87	18.76	275.77	25.58	47.97	26.11	375.44
F28	1.60	16.08	236.37	74.62			311.00
F29	0.26	2.69	39.54	89.21			128.76
F30	3.21	32.16	472.75	37.31		26.86	536.93
F31	2.14	12.86	189.10	16.79			205.89
F32	4.28	25.72	378.20	27.98			406.18
F33	2.68	16.08	236.37	8.95			245.33
Niuland Block							
F34	1.072	10.72	157.584	55.97	46.641		260.195
F35	1.34	13.4	196.98	59.701	52.238		308.919
F36	1.608	16.08	236.376	49.751	9.38		295.507
F37	2.144	21.44	315.168	13.992			329.16
F38	3.752	37.52	551.544	7.995			559.539
F39	1.608	16.08	236.376	37.313			273.689
F40	1.608	16.08	236.376	49.751			286.127
F41	1.608	16.08	236.376	55.97	43.532	22.388	358.266
F42	2.68	26.8	393.96	33.58	29.85	22.388	479.778
F43	1.072	6.432	94.5504	33.58			128.1304
F44	2.68	16.08	236.376	33.58			269.956

3.2 Comparison of Energy and Productivity between farmers

The energy and productivity for the four agricultural blocks i.e., Medziphema, Kuhuboto, Dhansiripar and Niuland is shown in Table 5. It was found that the most efficient farmer in Medziphema block is farmer 5 with input energy of 1416.06 MJ/ha and total productivity of 2686.567 kg/ha. In Kuhuboto, farmer 1 is the most efficient with energy input of 1802.542 MJ/ha and productivity of 2238.81 kg/ha. In Dhansiripar block, farmer 7 is the most efficient with energy input of 1410.552 MJ/ha and productivity of 1576.044 kg/ha. In Niuland block, farmer 1 is the most efficient with the input energy of 1416.296 MJ/ha and productivity of 1585.521 kg/ha.

3.3 Energy Productivity amongst blocks

Energy Productivity is the ratio of productivity obtained in (kg/ha) and the input energy in (MJ/ha) shown in Figure 2 below. It was observed that the energy productivity value for Medziphema, Kuhuboto, Dhansiripar and Niuland was found to be 1.27 kg/MJ, 0.94 kg/MJ, 0.73 kg/MJ and 0.87 kg/MJ respectively, which indicates that the productivity in Medziphema block was more efficient.

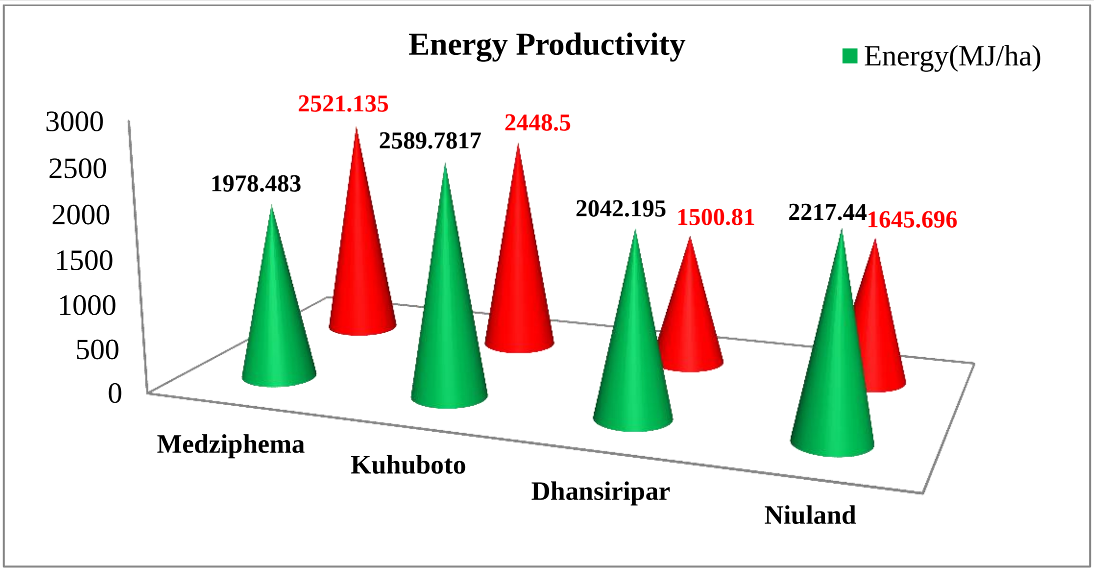

Fig. 3: Energy productivity in different block

Table 5: Energy and Productivity amongst farmers for 4 different blocks

Sl. No of Farmers	Medziphema		Kuhuboto		Dhansiripar		Niuland	
	Energy (MJ/ha)	Productivity (kg/ha)	Energy (MJ/ha)	Productivity (kg/ha)	Energy (MJ/ha)	Productivity (kg/ha)	Energy (MJ/ha)	Productivity (kg/ha)
F1	2069.472	2565.299	1802.542	2238.81	1981.041	1425.856	1416.296	1585.821
F2	1478.090	2155.887	2288.114	2404.643	1497.012	1279.318	1512.71	1641.791
F3	2074.684	2636.816	1994.339	2398.721	1089.026	1026.119	1318.741	1368.159
F4	1903.285	2313.433	2138.723	2309.879	1691.764	1616.915	1435.548	1492.537
F5	1416.03	2686.567	1910.4986	2300.995	1396.135	1279.317	1891.927	1652.452
F6	2085.240	2870.264	3201.947	2905.075	1236.330	1243.781	978.933	932.835
F7	1869.68	2388.06	2332.418	2353.617	1410.552	1576.044	1788.908	1741.293
F8	1848.103	2238.806	2495.864	2254.353	1577.013	1305.970	1536.043	1554.726
F9	1785.2674	2425.373	2518.032	2294.776	2754.948	2332.089	2879.823	1940.298
F10	1925.821	2487.562	2896.824	2985.075	1516.366	1632.463	2421.503	2332.089
F11	2749.0224	2964.423	2590.49	2487.562	1705.458	1791.045	2203.922	1865.672

3.4 Energy Productivity in terms of land holdings

The marginal farmer has the highest productivity per unit of energy utilised with the value of 1.117 kg/MJ while the larger land holder has the lowest productivity of 0.872 kg/MJ.

CONCLUSIONS

It was found that the total energy utilization for the production of rice were found to be 1978.483 MJ/ha, 2589.7817 MJ/ha, 2042.195 MJ/ha and 2217.44 MJ/ha for Medziphema, Kuhuboto, Dhansiripar and Niuland respectively with the productivity of 2.5, 2.4, 1.5 and 1.6 tonnes/ha. For the Medziphemablock direct and indirect energy were found to be 1738.66MJ/ha and 239.823 MJ/ha, for Kuhuboto it was found to be 2208.886 MJ/ha and 380.8957 MJ/ha, for Dhansiripar it was found to be 1650.587 MJ/ha and 391.608 MJ/ha and consecutively for Niuland it was found to be 1894.777 MJ/ha and 322.661 MJ/ha. It was also found that the numbers of marginal, small, medium and large farmers were found to be 1, 17, 19 and 7 respectively showing thatmajority of the farmers in the four blocks has medium land holdings.

Acknowledgements

Our sincere gratitude to our institute, School of Engineering Technology and Management, Nagaland University, Dimapur, Nagaland, for giving us the privilege to pursue our project. We also extend out sincere thanks to our supervisors for their immense help, constant encouragement and useful discussions. Special thanks are accorded to all the farmers of the four agricultural blocks for their cooperation and help during survey and data collection.

REFERENCES

1. Anonymous, Annual Report., *Indian Institute of Horticultural Research (IIHR), Bangalore* (2006-07),
2. Bridges, T.C. and Smith, E.M., A method of determining the total energy input foragricultural practices. *Transactions of the ASAE:* 781–784 (1979).
3. Choudhury, A.U., Some bird records from Nagaland, North-East India. Forktail **17:** 91-103 (2001).
4. Heslop, L.C. and Bilanski. W.K., Productive worth of different tillage machineryacross soil types. *ASAE Paper* No. 89-1615. St. Joseph, MI: ASAE (1989).
5. Sita, K.D. and Ponnarasi. T., An Economic Analysis of Modern Rice Production Technology and its Adoption Behaviour in Tamil Nadu. *Agricultural Economics Research Review*, **(22):** 341-347 (2009).
6. Lal, B., Rajput, D.S., Tamhankar, M.B., Agarwal, I. and Sharma. M.S., Energy useand output assessment of food-forage production systems. *J. Agronomy & Crop Science* **189:** 57-62 (2003).
7. Mittal, V.K., Mittal, T.K. and Dhawan, K.C., Research Digest on Energy Requirement on Agricultural Sector.Co-ordinating Cell, *AICRP on Energy Requirements in Agricultural Sector*. Punjab Agricultural University, Ludhiana, India (1985).
8. Neha, S., Murty, N.S., Pawan, M. and Bhardwaj, S.B., An analysis on the yield and yield contributing characters of rice in tarai region of Uttarakhand. *International Journal of Chemical Studies*, **6(3):** 42-47 (2018).
9. Sakshi. and Khajuria. S., Agricultural Productivity in India: Trends, Challenges and Suggestions. *International Journal of Science and Research (IJSR)*, ISSN: 2319-7064 (2015).
10. Salami, P., Ahmadi, H. and Keyhani, A., Estimating the energy indices and profitability of strawberry production in Kamyaran zone of Iran. *Energy Res J*, **1(1):** 32-5 (2010).
11. Singh, H., Misha, D., Nahar, N.M. and Ranjam, M., Energy use pattern in production agriculture of a typical village in arid zone, India: Part II. *Energy Conversion and Management,***44(7):** 1053-1067 (2003).
12. Singh, G., Relationship between mechanization and productivity in various parts of India.*Agricultural Mechanization in Asia, Africa and Latin America*, **32(2):** 68-76 (2001).
13. Stout, B.A., Handbook of energy for world agriculture. London: *Elsevier Applied Science*; P.21 (1990).
14. Swanton, C.J., Murphy, S.D., Hume, D.J. and Clements, D.R., Recent improvements in the energy efficiency of agriculture: Case studies from Ontario, Canada. *Agricultural Systems*, **52:** 399-418 (1996).
15. Vinten-Johansen, C., Lanyon, L.E. and Stephenson, K.Q., Reducing energy inputs to a simulated dairy farm. *Agriculture, Ecosystems and Environment,* **31:** 225-242 (1990).
16. Virk, P.S., Khush, G.S. and Peng, S., Breeding to Enhance Yield Potential Rice at IRRI. *The Idotype Approach*, 5-9 (2004).
17. Yilmaz, I., Akcaoz, H. and Ozkan, B., An analysis of energy use and input costs for cotton production in Turkey. *Renewable Energy*, **30:** 145-55 (2005).