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Status of farm mechanization and energy use efficiency of wheat crop in Ballia district of Uttar-Pradesh

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Abstract
Farm mechanization plays a vital role in timeliness of different farm operations. In areas of intensive agriculture, where two or more crops are taken in a year use of machinery can greatly enhance the productivity by timely performers of various agricultural operations and thereby improving the input use efficiency. This is the most capital intensive agricultural input. The highly populated state should progressively adopt power farming for timely and precise field operations at reduced costs and maximize utilization efficiencies of costly inputs for conservation of natural resources. Precision land leveling and use of efficient irrigation equipment for economizing in water requirements of crops including diversification of crops suiting to water availability are important issues in the region. It has been talked for long that there must be full mechanization of farms to fetch higher returns and reduction of human labor. But for a country like India with plenty of labor force, does mechanization really help in attaining a better yield due to timeliness of operations. The study has been undertaken particularly for district Ballia of U.P as there has been no work done on the assessment of energy use efficiency and mechanization level of wheat crop in this region.

Keywords: Farm mechanization, precision, energy use efficiency, wheat

1. Introduction

The global climate change and shift in food consumption towards high-value commodities are putting immense pressure on the Indian agriculture to produce more and efficiently for improving food and nutritional security while reducing the environmental footprints. The growth in Indian agriculture has been moderate (3% per annum) in the past one decade. But, there have been some structural shifts in terms of composition of output. There are increasing trends towards commercialization and diversification of agriculture (Joshi *et al*., 2007) [12]. On the input side, there is increasing inclination towards the use of modern inputs and farm mechanization. These developments have significant implications for energy-use in agriculture. Modern inputs and mechanization require more commercial energy and this holds true for the management of perishable commodities also. This implies a significant change in energy-use pattern in the Indian agriculture. This coupled with rising requirement of commercial energy in the non-agricultural sectors is escalating the demand for more energy. Globally also, there is again a rising trend in oil prices and countries are looking for alternative sources of energy and energy efficient technologies. Both energy use and costs are ever-increasing in the agricultural sector. Since the green revolution and the promotion of high-input, mechanized, irrigated cropping systems, agriculture uses much energy, directly and indirectly, owing to its many production activities, inputs and requirements: land preparation, tillage, fertilizers and agrochemicals (manufacturing and application), irrigation (pumping), harvesting and the likes. Therefore, increased energy efficiency has become a key objective for both farmers and policymakers; however, on-going efforts fall short of harnessing the complete economic potential of energy use in agriculture. Wheat (*Triticum aestivum* L.) is a main cereal crop cultivated throughout the world along with rice, maize, barley, rye, sorghum, oats and millet. It is grown under irrigated as well as rainfed conditions worldwide. Based on Ministry of Agriculture and Farmers Welfare of India statistics, India produced about 98.38 million tonnes of wheat in 2016-17. Energy is one of the most valuable inputs in agriculture for crop production. Agriculture itself is an energy consumer and energy supplier in the form of bio-energy (Alam *et al*., 2005) [1]. A higher input of energy accounts for higher energy costs, which significantly reduces the net return of the farms and is a challenging issue for the policy makers. In many advanced agricultural systems, an increase in yield is clearly the result of an augmented energy input that is directly related to the use of improved mechanized tools and the introduction of high-yield crop varieties. To know more about the energy input and output relationship in the agricultural sector, it is necessary to take account of the proper use of various energy sources, the cost of energy usage and its impacts on the environment (Jones, 1989) [11]. To meet the increasing food demand of the ever increasing population of the world, the world's production capacity is expected to increase two folds by 2050 (FAO, 2018) [7] and energy use will be a prime factor in this transformation as the amount of arable land will either decrease or will remain constant.

Total geographical area of the Uttar Pradesh is 24,170 thousand ha (which is 7.33% of total area of India) out of which 16,573 thousand ha is under cultivation. Gross cropped area is 25,414 thousand ha with the cropping intensity of 153%. In Uttar Pradesh size of holding is around 0.83 ha and per capita land area is 0.14 ha, which is less than a half of the national average of 0.32 ha. Uttar Pradesh is largest producer of wheat, potato, sugarcane and milk whereas third largest producer of rice. Agriculture constitutes the backbone of the state economy because it provides livelihood to about two-third population of the state. The state is endowed with ample alluvial soil along with diverse agro-climatic profile which can support the cultivation of variety of crops. Due to large cultivated area, its share in national agricultural production is quite impressive but low crop productivity has hindered the realization of ultimate potential. (Anon., 2009) [2].

Uttar Pradesh is the largest state with maximum contribution towards national production (35.03%) from a large area (35.12%), but with productivity on a lower side of 2.7 tonnes/ha. The wheat production is distributed in three agro climatic zones, *viz*. western Uttar Pradesh (3.29 million ha), eastern Uttar Pradesh (5.24 million ha) and central Uttar Pradesh (0.68 million ha). The yield gap between farmers' fields and frontline demonstration is 1.35 tonnes/ha. The area is 9.2 million ha, with a production of 24.5 million tonnes and productivity of 2.7 tonnes/ha. The trend during the last five years has shown a marginal decline in production and productivity from nearly stable area of cultivation. The major constraints in production are decreased soil organic carbon status, nutrient mining, Imbalanced fertilization, crop residue burning leading to nutrient and organic carbon loss, declining water table and late sowing under sugarcane-wheat and after potato in western Uttar Pradesh. (ICAR Report 2018) [10]. Wheat requires very high inputs in terms of agricultural machinery, pesticides, fertilisers and other agro-chemicals (Singh and Chancellor, 1975) [19]. Currently, cropping of wheat crop increasing their energy inputs; therefore, there is a require to ascertain the efficiency of the crop in terms of energy use. In this context, it is imperative to thoroughly budget the energy use of the widely followed crop systems to identify the processes and systems that are most energy consuming and can be replaced with other low input-energy-consuming practices, in order to conserve energy and achieve sustainable cropping systems (Hatirli, 2006) [9]. The farm size distribution in Indian farming households has gone to a major shift, with the percentage of marginal, small and small & marginal categories witnessing an increase while the semi medium, medium and large farm sizes witnessing a continuous decrease, after the post-independence period (Dev, 2012) [6]. There has always been a lot of debate on the economic and environmental performance of smaller farms as compared to larger farms. The study also intends to report the performance of marginal, small and medium farms, in terms of energy indicators. There have been several studies to assess the energy performance of different crops and cropping systems in Upper Indo- Gangetic Plains (Singh *et al*., 1990; Nassiri and Singh, 2009) [20, 16]. However, there are a limited number of studies assessing the key energy indicators performance of crop systems in the middle Indo-Gangetic plains (Mittal *et al*., 1985; Tripathi *et al*., 2005) [15, 8]. Therefore, to assess energy indicators, such as energy input energy output and Energy Use Efficiency (EUE), (in terms of the yield of main products) in the district Ballia of state Uttar Pradesh India.

The energy agriculture relationship is becoming more and more important with the intensification of the cropping systems, which is considered to be the only means of raising agricultural output in land scarce situations. Timely solving the problems and large scale implementing the approaches of developing the agricultural energy system will contribute to independence of energy supply for overcoming the energy crisis and reviving national farming, which will be a considerable input in ensuring the national food security. Therefore, the present study was undertaken with the objective to analyze the input, output and to identify energy efficiency for satisfactory energy output.

2. Material and Methods

The primary data for energy input resources were collected by field surveys and personal interview of farmers through questionnaire. Secondary data for energy input resources and energy outputs were obtained from the available information in literatures and other resources The mechanical energy dissipated in mechanical operations and energy consumed in other activities, such as irrigation, transportation and other inputs, were estimated from on- and off-farm energy input.

2.1 Site Description

Ballia district of Uttar Pradesh was chosen for the study which is located at 25.8307° N, 84.1857° E and falls under agro-climatic east plain zone of Uttar Pradesh characterized by semi dry medium moisture availability with 180–210 days growing season and sub-humid climate with two dry season i.e. summer and winter and erratic soil moisture regimes. There are 17 blocks in Ballia District Uttar Pradesh. It has a total reported area of 299265 ha out of which 215498 ha, (72%) is net sown area, 42989 ha (14.36%) under land utilized other than agriculture, 22419 ha (7.49%) current and other fallow, 1248 ha (0.4%) cultivable waste land and 5792 ha. Total net sown area covers 74.99, 83.33 and 3.0 per cent in Kharif, Rabi and Zaid crop, respectively with 79.58 per cent irrigated area. The total 171485 ha (79.58%) of net sown area are irrigated, out of which major area (76.42%) irrigated with private tube well under sure irrigation which is more potential for diversification (Anon. KVK Ballia). The major crop gown in the area of Ballia district was wheat followed by Paddy, Lentil, Potato, pigeon, Chick pea, Field pea, Sugarcane and Maize.

2.2 Energy Use

The survey of about 200 farmers were conducted in order to collect data which was divided in three major categories on the basis of size of land, input power used and the yield along with other economic factors such as cost of cultivation, machinery cost, cost of human and animal labour etc.

2.2.1 Calculation of energy input

The amount of inputs used in the production of wheat crop (chemicals, human labor, machinery, seed, manure, fertilizers, fuel, electricity and irrigation water) were specified in order to calculate the energy equivalences in the study (Table 1). The amounts of input were calculated per hectare and then, these input data were multiplied with the coefficient of energy equivalent as given in Eq. 1.

Energy Input (MJ/ha) = Use of Input (unit) × Energy Equivalent (MJ/unit) (1)

Table 1: Energy coefficients (MJ/h) for various equipments used in input and output of wheat production (Nassiri and Singh, 2009) [16]

Power source	Equipment Energy coefficient (MJ/ h)
Manual	
Spade	0.314
Sickle	0.031
Sprayer	0.502
Tractor drawn	
MB plough	2.508
Cultivator	3.135
Disk plough	3.762
Planter	9.405
Disk harrow	7.336
Seed drill	8.653
Reaper	5.518
Rotavator	10.283
Others	
Combine harvester	47.025
Thresher	7.524
Centrifugal pump	1.750
Electric motor 35 hp	0.343
Electric motor (others)	0.581
Diesel engine	0.216
Tractor (>45 hp)	16.416
Tractor (others)	10.944
Self-propelled combine harvester	171.000

2.2.2 Calculation of energy output

The amounts of output of wheat crop (grain and straw as by product) were specified in order to calculate the energy equivalences in the study as given in Eq. 2. The amounts of output were calculated per hectare and then, these output data were multiplied with the coefficient of energy equivalent (Table 2).

Energy output (MJ/ha.) = {grain production (kg/ha) × Energy Equivalent (MJ/kg) + by product production (kg/ha) × Energy Equivalent (MJ/kg)} (2)

Table 2: Energy equivalents for various input and output energy forms

Component	Unit Energy equivalent coefficient (MJ/unit)	Source
Human labor		
Adult male, Man-h	2.00	Soni *et al*. (2013) [21]
Female Wo, man-h	1.60	Soni *et al*. (2013) [21]
Children, Child-h	1.00	Taewichit (2012) [21]
Diesel, lt.	56.30	Nassiri and Singh (2009) [16]
Electricity, kWh	11.93	Nassiri and Singh (2009) [16]
Chemical fertilizers		
Nitrogen, kg	60.60	Kuswardhani *et al*. (2013) [14]
P_2O_5, kg	11.10	Chaudhary *et al*. (2009) [4]
K_2O, kg	6.70	Chaudhary *et al*. (2009) [4]
Farm Yard Manure (FYM), kg	0.30	Kizilaslan (2009) [13]
Seeds		
Cereals, kg	14.70	Nassiri and Singh (2009) [16]
Straw, kg	14.70	Nassiri and Singh (2009) [16]
Seeds (Cereal), kg	14.70	Hatirli (2006) [9]
Agro-chemicals		
Inferior chemicals, kg	10.0	Nassiri and Singh (2009) [16]
Zinc Sulphate, kg	20.90	Taewichit (2012) [22]

2.2.3 Energy use efficiency (EUE)

EUE measures the energy input and output efficiency of a crop production system, where the output is computed as the production of the main product and its byproducts as given in Eq. 3.

EUE= Total Output Energy (MJ/ha)/Total Input Energy (MJ/ha) (3)

2.3 Calculation of Farm Power Availability
A total of 200 farmers were interviewed through pre-designed questionnaire. Farm power availability was calculated by summing farm powers available from mechanical and animal power sources per hectare of operational land holding. The average farm power availability was worked out for the districts using Eq. 4 given below:

Avg. farm power availability =
{(Number of agricultural Worker × 0.05) + (Number of Tractors × 26.1) + (Number of electric motor ×3.7) + (Number of diesel engine × 5.6)} / Available cultivated land (ha) (4)

2.4 Analysis of Data
The data was analyzed using MS Excel 2007 software of Microsoft.

3. Results and Discussion
3.1 Energy Use Efficiency in the wheat production
3.1.1 Energy inputs in the land preparation for wheat production
Wheat cropping systems required 1060.57 MJ/ha of the energy input in terms of land preparation (Table 3) For the land preparation the large segment of energy was consumed by the diesel as a fuel 942.406 MJ/ha. This is due to the use tractors for ploughing their field.

Table 3: Energy consumption in the field preparation

Energy Consumption	Tractor	Man	Fuel	Implement
Land Preparation, MJ/ha	75.157	13.74	942.406	29.286

3.1.2 Energy inputs in the sowing for wheat production
Wheat cropping systems required 2138.39 MJ/ha of the energy input in order to sow wheat seeds as shown in Fig. 1. The seed rate of wheat crop is about 100-120 kg/ha and it consumed highest amount of energy of 1781.64 MJ/ha.

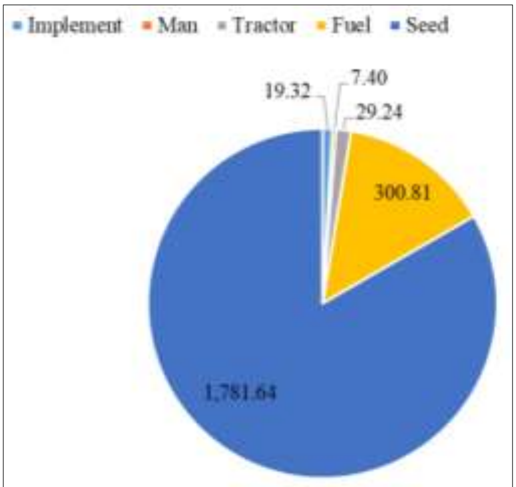

Fig 1: Energy consumption required for the sowing operation in the wheat crop production

3.1.3 Energy inputs required for the irrigation in the wheat production
Wheat cropping systems required 3298.38 MJ/ha of the energy input as given in Table 4. Highest energy consumption was found to be in the form of fuel in the wheat crop production followed by electric power. The reason could be the higher use of diesel engine for the application of water.

Table 4: Energy consumption required for the irrigation in the wheat crop production

Energy Consumption	Man	Diesel engine	Electric motor	Fuel	Centrifugal pump	Electricity
Irrigation, MJ/ha	253.02	31.62	1.90	2665.66	110.69	235.50

3.1.4 Energy inputs in chemical and fertilizer for wheat production
Energy consumption in the form of chemical and fertilizer for the wheat crop production is shown in Fig. 2. Wheat cropping systems required 8254.19 MJ/ha of the energy input in the form of chemical and fertilizers consumption. The result showed that the application of nitrogen was found to be highest as 7416.83 MJ/ha followed by phosphorous.

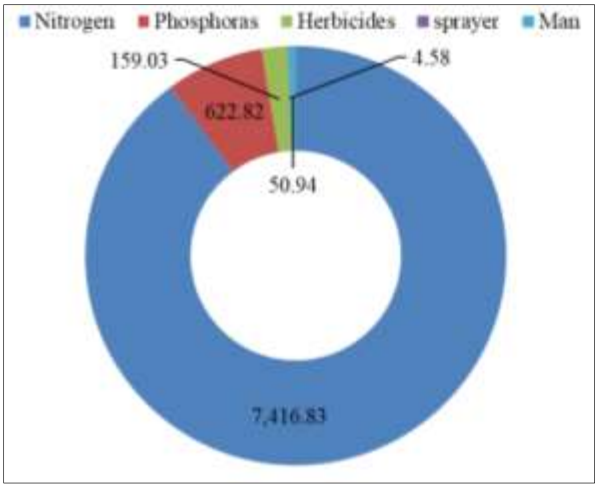

Fig 2: Energy consumption required for the chemical and fertilizer in the wheat crop production

3.1.5 Energy inputs required for the harvesting operation in the wheat production
Energy consumption for the harvesting operation in the wheat production was studied. It was observed that female farm worker was more involved in the harvesting than male farm worker as shown in Fig. 3.

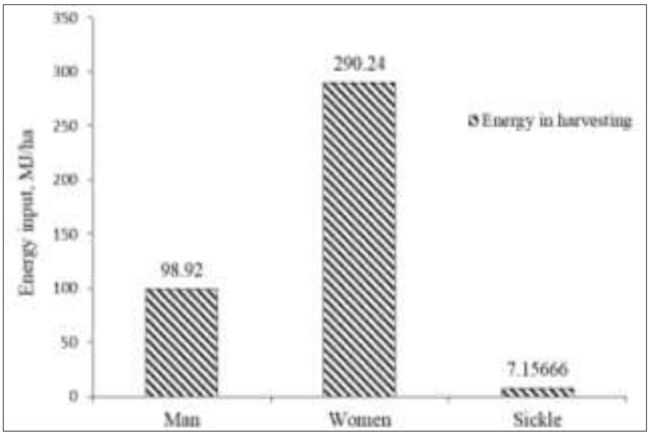

Fig 3: Energy Consumption required in the harvesting operation

3.1.6 Energy inputs in the threshing operation for wheat production

Energy input required for the threshing wheat crop is shown in Fig. 4. It was observed that the diesel engine was most useful power source in terms of energy consumption for threshing the grain of wheat crop.

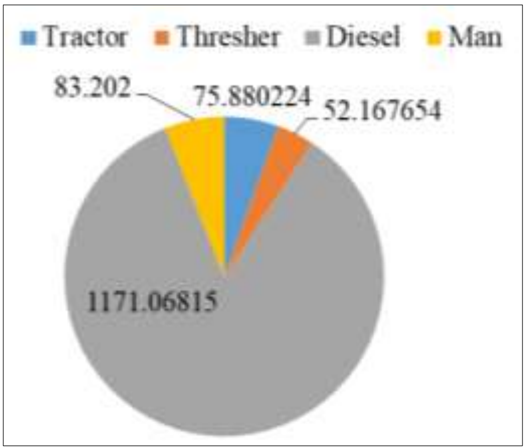

Fig 4: Energy consumption for the threshing operation

3.2 Energy Output from the Wheat Production

Grain yield and by-products (straw) were two forms of energy output in the wheat production as given in Table 5. The total energy output from the wheat cropping system was found to be 98181.3 MJ/ha.

Table 5: Energy output from the wheat crop production

Energy	Grain yield	By-product
Output, MJ/ ha	48363	49818.3

3.3 Effect of Different Land Sizes on the Energy Use Efficiency

The effect of different land sizes on energy use efficiency was also assessed and analyzed statistically. In the Wheat production EUE was found maximum in the larger land category with the average value of 6.44 and it showed a reducing trend as the land sizes decreased. The EUE decreased to an average value of 5.76 for Small land holdings and again further reduced to 5.61 in the marginal land holdings. The average farm size in the India is becoming smaller, and small land holdings are becoming predominant. In both the systems, a trend of increasing input energy was observed with the decrease in farm size. Input energy in the form of human power decreased as the land size increased, which clearly reflects the dependency of farmers with small land holdings on human labour. It was noted that use of farm labour was higher in the small land holdings. A similar result for use of human power in different land holdings in the Indo-Gangetic plains was reported by Nassiri and Singh (2009) [16] and Bohra (1998) [3]. The reduction in fuel use as the size of land holdings increased can be attributed to the productive time in using mechanized equipment. It was observed that farmers were not following the recommended dose of fertilizers, and the actual fertilizer application was dependent on the financial condition of the farmers. The productivity of the farms increased with the increase in farm size, which occurred because of the difference in the farming practices. The small farmers followed conventional farming methods, while the farmers with large holdings use advance machinery.

4. Conclusions

The District Ballia, Uttar Pradesh has the main occupation of the population residing is agriculture. The large area of the district is under wheat cultivation. The study aimed at evaluating the Wheat in this region in terms of their energy use and mechanization level of farmers Field. Data were collected from 200 farmers which were selected based on random method. Face-to face questionnaire method was used in obtained the data. Total energy consumption in wheat production was found 16658.58 MJ/ha whereas energy output was calculated as 98181.3 MJ/ha. The highest input energy item was determined as chemical and fertilizer as 8254.20 MJ/ha. Irrigation of field required about 3318.15 MJ/ha of energy input. The overall energy use efficiency of wheat crop was found to be 5.94%.

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