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LEVEL AND PATTERN OF ENERGY CONSUMPTION IN AN AGRICULTURALLY ADVANCED AREA OF UTTAR PRADESH

L. R. Singh and Brijendra Singh*

With the introduction of new farm technology the prospects of increasing productivity per hectare have brightened. The short duration high-yielding varieties (HYV) have helped not only in attaining higher physical productivity but also in increasing the intensity of cropping and realise greater output per unit of area and time for which an approach is envisaged known as multiple cropping programme. The intended objective, however, could be successfully attained only through the adoption of package of improved practices as also timely completion of various farm operations. It is in this context that the farm power acts as one of the most important determinants for successful execution of multiple cropping programme. The level of farm power use and its composition differ markedly on different categories of farms depending upon the level of size of holdings, the magnitude of adoption of HYV and acquisition of other resources. This in turn has resulted in differential energy use per hectare on farms with different levels of farm mechanization. The quantitative estimates pertaining to energy use and its cost in the execution of various farm operations at different levels of farm mechanization are rather scanty. This study therefore is an attempt to estimate the energy use patterns and its cost on bullock and tractor operated farms in Nainital Tarai where the cultivation of HYV has been taken up in a big way so that the inferences drawn from this study pertaining to energy use may be more relevant in the context of new farm technology—which stands as the prime hope for our agricultural development.

METHODOLOGY

The information used for the present study was procured from a survey† conducted in five purposively selected villages in Rudrapur block of Nainital district during the year 1974-75. The original sample of 25 farmers representing small (less than 3 hectares), medium (3 to 6 hectares) and large (6 to below 12 hectares) selected randomly from these five villages were reclassified into two categories, *i.e.*, bullock farm and tractor farm.

The energy used in different farm operations supplied by different power sources and the cost of energy were calculated as follows. To make energy supplied through various sources—human, bullock and mechanical—comparable their power was converted into energy on the assumption that one adult man on an average develops 0.10 horse power and one pair of bullock deve-

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† The data used are taken from a survey under I.C.A.R. sponsored "Co-ordinated Scheme on Energy Requirements in Intensive Agricultural Production" conducted by the G. B. Pant University of Agriculture and Technology, Pantnagar.

lops 1.00 horse power. In case of mechanical power sources, their rated horse power was taken into account. To work out the cost of family labour, the hiring rates of these items were used. The cost of hired human labour, bullock labour as well as hired machines used in different farm operations was calculated at the prevailing rate in the study area. The canal irrigation water was also converted as equivalent to tube-well irrigation water, for calculating the energy as per the following formula:

$$\text{Energy} = \frac{\text{No. of irrigation} \times \text{Assumed depth of water in inches} \times \text{Area of plot in acres} \times 22{,}688 \times 5 \text{ h. p.}}{\text{Assumed discharge per hour of 5 h.p. electric motor pump (11,000 gallons)}}$$

where, 22,688 gallons=volume of one acre-inch irrigation water.

Farm Size and Availability of Power

The average farm size and availability of permanent labour, bullock labour, tractor and irrigation equipment on the bullock and tractor operated farms are given in Table I.

TABLE I—TOTAL MANUAL, BULLOCK AND MECHANICAL POWER ON BULLOCK AND TRACTOR OPERATED FARMS

Sr. No.	Type of farms	No. of farms	Average operated area (hectares)	No. of human labour		Bullock power in number of pair	Tractor number	No. of private tube-wells	
				Family	Hired permanent			Electric operated	Diesel operated
1.	Bullock	16	3·68	57	9	20	—	4	3
2.	Tractor	9	6·82	11	19	11	9	6	2

Even though the per farm operational area is about 85 per cent higher on the tractor operated farms, the human labour availability is much higher on the bullock operated farms. The tractor operated farms depend to a noticeable extent on permanent hired labour while for the bullock operated farms, family labour is the main permanent labour source. The tractor operated farms are fully conscious of the positive rolé of irrigation input in farm production in the context of new farm technology and almost every one has acquired mechanical sources of irrigation while on the bullock operated farms only 40 per cent of the farmers are having their own irrigation equipments in the form of diesel and electric pumping sets.

INTENSITY OF ENERGY USE AND ITS COMPOSITION

The per hectare energy input in its various forms—manual, bullock and mechanical—and energy cost along with its operational distribution for the major crops and the farm business as a whole on the bullock and tractor operated farms are presented in the following section.

Paddy HYV

The total energy use per hectare on the tractor operated farms was higher as compared to that on the bullock operated farms (Table II). The energy used through mechanical power constituted only 72.6 per cent of the total energy used on the bullock farms as against as high as 87.52 per cent on the tractor farms. The tractor operated farms by laying more emphasis on land preparation as also on inter-culture operation coupled with higher fertilizer application had realised more yield which necessitated higher energy use in harvesting operation than that needed on the bullock farms. The substitution of manual and animal power through mechanical power in tillage operation has helped to reduce substantially the energy cost per hectare as a whole.

Wheat HYV

In wheat HYV also, the energy use per hectare was higher on the tractor operated farms than that on the bullock operated farms (Table III). The energy supplied through mechanical power constituted 98.17 per cent and 84.41 per cent on the tractor operated and bullock operated farms respectively. Mechanical energy was used for land preparation, irrigation, threshing and transport on the tractor operated farms and for irrigation, threshing and partly for land preparation (through hiring in tractor services) on the bullock operated farms. Owing to cheaper sources of mechanical energy use in tillage operation these tractor operated farms incurred less expenditure in the execution of tillage and sowing. However, higher emphasis on inter-culture, and fertilizer application on the tractor farms have resulted in obtaining more yield and thereby in more energy use and energy cost in harvesting and threshing operations.

Sugarcane Planted

In sugarcane crop also the level of energy use per hectare was higher on the tractor operated farms than that on the bullock operated farms (Table IV). This difference in the energy use pattern is more pronounced in land preparation. The mechanical energy use in land preparation constituted a significant part of total energy use on the tractor operated farms. The mechanical energy use constituted 68.73 per cent and 57.21 per cent of the total energy use on the tractor operated and bullock operated farms respectively. The tractor operated farms have not made matching reduction in animal and

TABLE II—ENERGY AND ENERGY COST PER HECTARE FOR HYV PADDY (IRRIGATED)

Operations	Manual power		Bullock power		Mechanical power		Total		Fertilizer cost (Rs.)	Yield (quintals)
	Energy (H.P. hrs.)	Cost (Rs.)	Energy (H.P. hrs.)	Cost (Rs.)	Energy (H.P. hrs.)	Cost (Rs.)	Energy (H.P. hrs.)	Cost (Rs.)		
Bullock operated farms										
Land preparation	18.78	117.40	744.08	144.08	105.40	73.19	268.26	334.67	472.46	46.11
Sowing	25.33	158.35	—	—	—	—	25.33	158.35		
Fertilization and manuring	1.78	11.15	3.04	3.04	—	—	4.82	14.19		
Irrigation	8.08	50.55	—	—	597.86	162.03	605.94	212.58		
Plant protection measures	0.62	3.90	—	—	—	—	0.62	3.90		
Inter-culture	22.17	138.60	—	—	—	—	22.17	138.60		
Other pre-harvesting operations	1.12	7.05	—	—	—	—	1.12	7.05		
Harvesting	24.60	153.75	—	—	—	—	24.60	153.75		
Transportation	4.08	25.50	—	—	—	—	4·08	25.50		
Threshing and winnowing	9.19	57.45	7.36	7.36	13.07	7.46	29.62	72.27		
Total	115.75	723·70	154.48	154.48	716.33	242.68	986·56	1,120.86		
Tractor operated farms										
Land preparation	4.42	27.65	16.32	16.32	576.16	81.43	596.90	125.40	870.71	55.13
Sowing	37.31	233.20	—	—	—	—	37.31	233.20		
Fertilization and manuring	1.63	10.20	—	—	—	—	1.63	10.20		
Irrigation	6.37	39.85	—	—	457.56	65.89	463.93	105.74		
Plant protection measures	0.45	2.85	—	—	0.66	0.35	1.11	3.20		
Inter-culture	36.80	230.00	—	—	—	—	36.80	230.00		
Other pre-harvesting operations	4.02	25.15	—	—	—	—	4.02	25.15		
Harvesting	25.90	161.90	—	—	—	—	25.90	161.90		
Transportation	4.31	26.95	—	—	—	—	4.31	26.95		
Threshing and winnowing	10.06	62.90	—	—	1.38	0.31	11.44	63.21		
Total	131.27	820.65	16.32	16.32	1,035.76	147.98	1,183.35	984.95		

TABLE III—ENERGY AND ENERGY COST PER HECTARE FOR HYV WHEAT (IRRIGATED)

Operations	Manual power		Bullock power		Mechanical power		Total		Fertilizer cost (Rs.)	Yield (quintals)
	Energy (H.P. hrs.)	Cost (Rs.)	Energy (H.P. hrs.)	Cost (Rs.)	Energy (H.P. hrs.)	Cost (Rs.)	Energy (H.P. hrs.)	Cost (Rs.)		
Bullock operated farms										
Land preparation	7.21	45.10	72.16	72.16	297.51	196.99	376.88	314.25	608.79	28.61
Sowing	1.36	8.55	9.36	9.36	60.25	41.73	70.97	59.64		
Fertilization and manuring	0.98	6.15	—	—	—	—	0.98	6.15		
Irrigation	4.29	26.85	—	—	237.37	107.64	236.66	134.49		
Plant protection measures	0.24	1.50	—	—	—	—	0.24	1.50		
Inter-culture	8.38	52.40	—	—	—	—	8.38	52.40		
Other pre-harvesting operations	—	—	—	—	—	—	—	—		
Harvesting	17.64	110.30	—	—	—	—	17.64	110.30		
Transportation	4.60	28.75	3.92	3.92	—	—	8.52	32.67		
Threshing and winnowing	5.77	36.10	12.72	12.72	214.72	147.54	233.21	196.36		
Total	50.47	315.70	98.16	98.16	804.85	493.90	953.48	907.76		
Tractor operated farms										
Land preparation	2.78	17.40	1.28	1.28	1,069.11	274.84	1,073.17	293.52	881·09	36.90
Sowing	0.56	3.55	1.36	1.36	83.43	26.18	85.35	31.09		
Fertilization and manuring	1.44	9.00	—	—	—	—	1.44	9.00		
Irrigation	4.25	26.60	—	—	216.78	87.50	221.03	114.10		
Plant protection measures	—	—	—	—	—	—	—	—		
Inter-culture	22.49	140.60	—	—	—	—	22.49	140.60		
Other pre-harvesting operations	—	—	—	—	—	—	—	—		
Harvesting	21.13	132.10	—	—	—	—	21.13	132.10		
Transportation	5.25	32.85	5.68	5.68	—	—	10.93	38.53		
Threshing and winnowing	5.37	33.60	—	—	550.25	184.54	555.62	218.14		
Total	63.27	395.70	8.32	8.32	1,919.57	573.06	1,991.16	977.08		

TABLE IV—ENERGY AND ENERGY COST PER HECTARE FOR SUGARCANE PLANTED (IRRIGATED)

Operations	Manual power		Bullock power		Mechanical power		Total		Fertilizer cost (Rs.)	Yield (quintals)
	Energy (H.P. hrs.)	Cost (Rs.)	Energy (H.P. hrs.)	Cost (Rs.)	Energy (H.P. hrs.)	Cost (Rs.)	Energy (H.P. hrs.)	Cost (Rs.)		
Bullock operated farms										
Land preparation	9.28	58.00	92.80	92.80	262.85	167.14	364.93	317.94	413·74	570·00
Sowing	29.13	182.10	8.56	8.56	—	—	37.69	190.66		
Fertilization and manuring	1.13	7.10	—	—	—	—	1.13	7.10		
Irrigation	3.99	24.95	—	—	257.82	75.00	261.81	99.95		
Plant protection measures	—	—	—	—	—	—	—	—		
Inter-culture	25.71	160.70	—	—	—	—	25.71	160.70		
Other pre-harvesting operations	12.56	78.55	—	—	—	—	12.56	78.55		
Harvesting	86.84	542.80	—	—	—	—	86.84	542.80		
Transportation	10.85	67.85	108.56	108.56	—	—	119.41	176.41		
Total	179·49	1,122·05	209·92	209.92	520·67	242·14	910·08	1,574·11		
Tractor operated farms										
Land preparation	9.37	58.60	93.76	93.76	648.47	236.08	751.60	388.44	575.82	608.69
Sowing	29.92	186.40	2.56	2.56	—	—	32.38	188.96		
Fertilization and manuring	1.04	6.50	—	—	—	—	1.04	6.50		
Irrigation	3.12	19.55	—	—	188.94	161.73	192.06	181.28		
Plant protection measures	—	—	—	—	—	—	—	—		
Inter-culture	22.60	141.30	—	—	—	—	22.60	141.30		
Other pre-harvesting operations	2.77	17.35	—	—	—	—	2.77	17.35		
Harvesting	97.38	608.65	—	—	—	—	97.38	608.65		
Transportation	10.77	67.35	107.76	107.76	—	—	118.53	175.11		
Total	176·87	1,105·70	204.08	204·08	837·41	397·81	1,218·36	1,707·59		

TABLE V—ENERGY AND ENERGY COST PER HECTARE OF OPERATED AREA

Operations	Manual power		Bullock power		Mechanical power		Total		Gross income (Rs.)	Cropping intensity (per cent)
	Energy (H.P. hrs.)	Cost (Rs.)	Energy (H.P. hrs.)	Cost (Rs.)	Energy (H.P. hrs.)	Cost (Rs.)	Energy (H.P. hrs.)	Cost (Rs.)		
Bullock operated farms										
Land preparation	17.01	107.63	153.10	153.10	354.86	177.91	524.97	438.64	5,774.70	165
Sowing	15.06	94.09	16.47	16.47	60.62	31.74	92.15	142.30		
Fertilization and manuring	1.87	11.78	3.16	3.16	—	—	5.03	14.94		
Irrigation	5.77	34.48	—	—	498.52	133.66	504.29	168.14		
Plant protection measures	0.43	2.77	—	—	—	—	0.43	2.77		
Inter-culture	19.38	121.18	2.71	2.71	—	—	22.09	123.89		
Other pre-harvesting operations ..	7.32	45.76	—	—	—	—	7.32	45.76		
Harvesting	35.23	220.21	—	—	—	—	35.23	220.21		
Transportation	9.14	57.16	18.96	18.96	—	—	28.10	76.12		
Threshing and winnowing	13.53	84.56	22.93	22.93	134.66	69.61	171.12	177.10		
Total	124.74	779.62	217.33	217.33	1,048·66	412·92	1,390.73	1,409·87		
Tractor operated farms										
Land preparation	6.42	40.21	26.36	26.36	1,642.02	333.45	1,674.80	400.02	8,257.29	186
Sowing	24.88	155.57	4.55	4.55	104.11	23.62	133.54	183.74		
Fertilization and manuring	2.29	14.38	—	—	—	—	2.29	14.38		
Irrigation	8.06	50.38	—	—	733.42	149.22	741.48	199.60		
Plant protection measures	0.28	1.77	—	—	—	—	0.28	1.77		
Inter-culture	40.45	252.93	0.26	0.26	—	—	40.71	253.19		
Other pre-harvesting operations ..	9.58	59.93	—	—	—	—	9.58	59.93		
Harvesting	56.75	353.39	—	—	—	—	56.75	353.39		
Transportation	7.17	44.89	34.98	34.98	—	—	42.15	79.87		
Threshing and winnowing	9.34	58.37	1.04	1.04	521.39	140.72	531.77	200.13		
Total	165.22	1,031.82	67.19	67.19	3,000.94	647.01	3,233.35	1,746·02		

manual energy through use of mechanical energy in tillage operation. The higher fertilizer application has helped the tractor operated farms not only to compensate for the relatively lesser attention they paid in inter-culture but also in realising higher yield than that on the bullock farms.

Farm Business

Table V indicates that the land preparation, irrigation and threshing are the main farm operations consuming bulk of the energy use on the bullock and tractor operated farms. Energy use per hectare of operated area on the tractor operated farms is more than double of that on the bullock operated farms. The mechanical energy content is 92.81 per cent of the total energy use on the tractor operated farms as against 75.40 per cent on the bullock operated farms. The tractor power was primarily used for land preparation and the execution of this operation was done well on time (even with relatively higher operated area) which is reflected in higher intensity of cropping and income. The level of irrigation and inter-culture was higher on the tractor operated farms than that on the bullock farms. The net result of higher intensity of cropping, more emphasis on irrigation and inter-culture as also on fertilizer application is reflected in increased gross income on the tractor operated farms.

In spite of slightly higher cost of energy per hectare of operated area, the tractor operated farms were more efficient in conducting the farm operations and had realised Rs. 4.73 as against Rs. 4.09 for every rupee of investment in energy. This clearly demonstrates the scope for farm mechanization in enhancing the farm return in Tarai under the present state of farm structure.

CONCLUSION

Thus the following conclusions emerge from the analysis presented in the preceding sections.

1. Tillage operation consume the bulk of energy used in the production of crops. Irrigation and threshing are the other operations where too a sizeable amount of energy is used.

2. Bullock farms in the area are also using substantial portion of their total energy requirements in the form of mechanical energy in the execution of irrigation, threshing and partly for land preparation through hiring in tractor services.

3. Energy use per hectare of operated area on the tractor operated farm is more than double of that used on the bullock farms and approximately nine-tenth of the energy content is supplied through mechanical sources.

The bulk of mechanical energy is used in the execution of tillage, irrigation and threshing operation.

4. Acquisition of mechanical sources of farm power on the tractor farms helps in timely accomplishment of farm operations and realisation of higher cropping intensity which helps in the attainment of greater returns per unit of area and energy costs.

AN ECONOMIC ANALYSIS OF ENERGY REQUIREMENTS IN PUNJAB AGRICULTURE

A. J. Singh and S. S. Miglani*

Energy forms one of the most crucial inputs in agriculture, whatever be the source from which it is supplied—man, animal or machine. Energy requirements in agriculture vary according to the type of farming area, the size of farm and the level of technology. However, empirical studies in this direction are conspicuous by their absence. Besides, there is lack of knowledge regarding the productivity of different types of energy and the rates of substitution between them. This study was, therefore, undertaken in Ferozepur district of Punjab with the following objectives: (*a*) to examine the energy requirements from various sources for different categories of farms; (*b*) to analyse the marginal value productivities between different types of energies; and (*c*) to estimate the marginal rates of substitution between selected sources of energy as a guide to cost minimization.

METHODOLOGY

The study was located in Ferozepur district of the Punjab and multi-stage stratified random sampling design was adopted with villages as the primary and operational holdings as the ultimate units of study.[1] Based on the soil-climate-crop complex, Ferozepur district was stratified into three zones, *viz.*, maize-wheat, paddy-wheat and American cotton-wheat zones. The cultivated area in these zones worked out to be in the proportion of 3:5:7 respectively. The sample villages were, therefore, selected from these zones in this proportion. Thus three villages from maize-wheat, five from paddy-wheat and seven from American cotton-wheat zone were selected randomly with probability proportional to the cultivated area in each zone. As such a total of 15 villages was selected for this study.

The cultivated area in the selected villages was pooled and transformed to show the size ranges of operational holdings in five size-groups, *viz.*, below

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