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Energy utilization pattern in various agricultural operations for major cereal crops of Himachal Pradesh

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Abstract

A study was carried out in two major agro-climatic zones (sub-montaneous low hills sub-tropical i.e. zone-I and mid hills sub-humid i.e. zone-II) of Himachal Pradesh from 360 farming families to know the utilization pattern of farm power in terms of energy for different farm operations of major cereal crops. Total energy consumption in different agricultural operations such as seedbed preparation, sowing/planting, weeding and earthing up, harvesting, threshing/shelling and transportation was 3341 MJ/ha in which 918 MJ/ha from human, 944 MJ/ha from animal and 1478 MJ/ha from tractor for maize and 2466 MJ/ha (962 MJ/ha from human, 1068 MJ/ha from animal and 437 MJ/ha tractor) for paddy crop in zone-I, whereas in zone-II it was 3651 MJ/ha (1041 MJ/ha, 1055 MJ/ha and 1555 MJ/ha) for maize and 2670 MJ/ha (1010 MJ/ha, 1257 MJ/ha and 404 MJ/ha) for paddy crop. The wheat crop consumed higher energy 5204 MJ/ha and 6139 MJ/ha as compared to other crops in zone-I and zone-II, respectively due to thresher with tractor. The energy consumption was also observed higher in zone-II as compared to zone-I due to smaller size of plots. It clearly indicates that farm operations were performed with low energy in hills because of more use of animate power. Hence, it is difficult to complete the farm operations timely and precisely with minimum drudgery from energy available through different power sources. Thus, the major issues emerged are supplementation of energy input through suitable power source to ensure timeliness of farm operations and adequate farm mechanization for efficient utilization of inputs while considering farm mechanization in the hills.

Keywords: Mechanization, energy, utilization, cereal crops, hill.

Introduction

In Himachal Pradesh, agriculture bears a great significance as 90 per cent population in the rural areas depends directly or indirectly on it and contributing significantly to the state economy. The marginal and small farmers dominate the peasantry constituting more than 84 per cent of the farmers having an average holding of about 0.65 hectare. Still farmers use traditional tools and mostly rely on animate power for energy because of unique topography. The crops are grown under terrain in very small plots having average size in the range of 100-200 m^2 under rain-fed condition (Vatsa and Saraswat, 2003). The rain-fed condition forces the farmers to grow the crop in limited time and it is possible only if proper resources are available with farmers for timely sowing. The food grain production is very low i.e. 1500 kg/ha (Anonymous, 2003) inspite of providing moderns inputs like seed and fertilizer but these inputs are not utilized precisely and timely due to poor availability of farm power and equipments.

The researchers and institutions in different countries have carried out considerable amount of work on energy use in agriculture and it was observed energy input and production has positive correlation in increasing the yield (Ozkan *et al.*, 2004; Singh *et al.*, 1992). In recent years, the total energy consumption has also increased steadily with increasing demand of agricultural products. Total energy input in Indian agriculture increased by 5.4 times during 1951-1995 while the production during the same times increased by 3.6 times (Singh, 1996). No emphasis has yet been laid to modernize the farm through proper energy particularly with improved farm tools and equipment for augmenting the crop production in the hilly state of Himachal Pradesh. Thus, a study was carried out to know the utilization of energy with various power sources in different agricultural operations by the farmers.

Methodology

Two agro-climatic zones (sub-montaneous low hills sub-tropical i.e. Zone-I at elevation ranges from 350-650 m amsl and mid hills sub-humid i.e. Zone-II at elevation ranges from 651-1800 m amsl) of Himachal Pradesh were surveyed to know the utilization of farm energy sources in different operations of major crops. These zones were selected on the basis of net cultivated area because it represents 78 % of the net cultivated area of the state. From both the zones, data were collected from 360 farming families with the help of well-designed pre-tested questionnaire prepared for this purpose. Three stage stratified random sampling has been used to draw the sample of cultivators in which blocks were taken as first, villages as second and cultivators as final stage units. The information on the use of power source was recorded for each operation and crop. The crops selected were maize and paddy in Kharif and wheat during Rabi season. A computer based excel software package was used to tabulate the data collected during survey. The data collected from different households was scrutinized and unwanted data weeded out. The information was analyzed with respect to categories of farmers namely, Marginal (<1ha), small (1-2ha), medium (2-4 ha) and large (> 4 ha) to find out the energy consumption. Energy levels of different operations were calculated using field data and suitable energy conversion coefficients (Singh *et al*, 1996).

Results and Discussion

The crop-wise energy utilized from different sources in various operations at different categories of farms for both the zones is presented below:

Maize

Operation-wise energy utilization with various power sources on different categories of the farms for zone-I and II is presented in Table 1. Seedbed preparation required the maximum human energy (171.4 MJ/ha) at marginal farms and the minimum at large farms (54.4 MJ/ha) in zone-I.

Table 1. Energy consumption (MJ/ha) with various power sources on different categories of farms for maize in zone-I and zone-II

Operation	Zone- I					Zone- II				
	Marginal	Small	Medium	Large	Weighted Mean	Marginal	Small	Medium	Large	Weighted Mean
Seedbed Preparation										
Human	171.4	158.3	143.3	54.4	145.9	187.5	192.4	170.5	70.6	165.3
Animal	666.8	640.8	555.3	163.7	626.3	724.1	705.0	670.5	192.6	690.5
Tractor	598.9	367.1	753.4	1696.4	618.2	811.7	792.4	1063.0	1565.5	869.3
Sowing/ Planting										
Human	67.4	66.0	62.8	44.5	65.6	73.2	78.0	71.5	54.0	73.1
Animal	228.9	222.6	240.8	183.5	226.9	257.1	265.3	250.7	239.8	257.3
Tractor	77.3	58.0	154.6	309.2	92.7	58.0	58.0	96.6	231.9	69.5
Weeding										
Human	168.7	163.8	152.7	155.7	165.4	203.7	212.5	195.2	179.0	203.4
Animal	92.7	78.1	70.9	50.9	85.5	113.6	95.4	103.6	76.3	107.1
Earthing up										
Human	203.7	191.1	199.1	179.1	199.6	221.7	212.5	203.5	199.1	216.8
Harvesting										
Human	186.4	204.4	191.0	195.0	190.9	204.2	198.4	186.4	195.0	200.7
Shelling										
Human	92.8	98.5	90.7	79.8	93.2	110.3	117.2	115.4	106.4	112.1
Tractor	483.2	676.4	1063.0	1121.0	614.3	425.2	676.4	1082.3	1159.6	581.5
Transportation										
Human	56.5	62.8	55.6	46.6	57.2	71.3	67.8	63.9	60.9	69.3
Animal	4.5	4.5	7.3	9.1	5.08	0.0	0.0	0.0	0.0	0.0
Tractor	154.6	116.0	173.9	289.9	154.5	0.0	77.3	116.0	154.6	34.8
Total Energy	3254	3108	3914	4579	3341	3462	3749	4389	4485	3651

The tractor was used for tillage in the range of 367.1 to 1696.4 MJ/ha in all categories of farms. However, large farms made more use of the tractor in tillage as compared to other categories of farms which used more animal energy (555.3-666.8 MJ/ha) as compared to large farms (163.7 MJ/ha). Similar, energy utilization pattern was observed in zone-II but it was 8-23, 8-17 and 26-53 % higher in case of human, animal and tractor, respectively as compared to zone-I. The use of human, animal and tractor energy in sowing /planting was in the

range of 44.5-67.4 MJ/ha, 183.5-240.8 MJ/ha and 58.0-309.2 MJ/ha respectively in case of all categories of farms in zone-I but these power sources were not utilized with any equipment like planter/seed drill etc. Similarly, this operation needed 7-23 % higher energy in case of manual and animal power in zone-II. All the farm groups were using broadcasting method or seed dropping behind the plough for sowing/planting. Being a Kharif crop, weeding operation required the maximum human energy on marginal farms (168.7 MJ/ha) and minimum on medium farms (152.7 MJ/ha) in zone-I whereas in zone-II, the maximum was 212.5 MJ/ha in case of small farms and minimum of 179.0 MJ/ha for large farms.

Earthing-up was the operation where maximum human energy was 203.7 and 221.7 MJ/ha engaged in marginal farms in zone-I and II, respectively. Maize crop harvesting was done manually which required 186.4-204.4 MJ/ha in both the zones. Shelling was done by utilizing human energy in the range of 79.8-98.5 MJ/ha and tractor energy 483.2-1121.0 MJ/ha in zone-I whereas zone-II utilized 106.4-117.2 MJ/ha and 425.2-1159.6 MJ/ha. Human energy required for transportation of produce was 57.2 MJ/ha in zone-I and 69.3 MJ/ha in zone-II. Tractor energy was also utilized in the range of 116.0-289.9 MJ/ha in both the zones but the animal energy was utilized for 4.5-9.1 MJ/ha only in zone-I due to its comparatively flat topography.

The marginal farmers utilized the maximum human and animal energy of 947 MJ/ha and 993 MJ/ha followed by small (945 MJ/ha and 946 MJ/ha), medium (895 MJ/ha and 874 MJ/ha) and large farmers (755 MJ/ha and 407 MJ/ha) in zone-I. The tractor energy was utilized for the maximum of 3416 MJ/ha by large category of farmers followed by medium (2145 MJ/ha), marginal (1218 MJ/ha) and small (1314 MJ/ha) in zone-I. Similarly, in zone-II, small category of farmers utilized the maximum of 1079 MJ/ha and 1066 MJ/ha followed by marginal (1072 MJ/ha and 1094 MJ/ha), medium (1006 MJ/ha and 1024 MJ/ha) and large farmers (865 MJ/ha and 509 MJ/ha). It is also clear that the animate energy utilization was decreasing from marginal to large farms but the mechanical energy was increasing in both the zones. It indicates that the mechanical energy was supplemented in case of large farms to complete the farming operations timely. Overall energy utilization was 12, 10 and 5 % higher in case of human, animal and mechanical energy as the power source respectively in zone-II. The reason for higher energy utilization was smaller plots with higher vertical interval in zone-II, where higher turning time and more approach time from one plot to the other was required (Vatsa, 2006). Moreover, the total energy requirement from all sources for maize was 3341 MJ/ha and 3651 MJ/ha in zone-I and zone-II, respectively which is quite low for higher productivity as studied by Singh *et al.* (1992).

Paddy

Seedbed preparation required the maximum human energy i.e. 134.5 MJ/ha with small farms followed by marginal (129.7 MJ/ha), medium (118.7 MJ/ha) and large farms (79.0 MJ/ha) in zone-I whereas in zone-II it was the maximum in case of marginal (138.4 MJ/ha) followed by small (135.3 MJ/ha), medium (132.3 MJ/ha) and large farms (97.2 MJ/ha), and is presented in Table 2. The tractor was also used by all the categories of farms for seedbed preparation in the range of 230 to 1082.3 MJ/ha in zone-I and 251.2- 1275.6 MJ/ha in zone-II. However, large farms used more tractors in tillage as compared to other categories of farms, which used more animal energy as compared to large farms. Energy utilization was observed to be 6-18 and 5-19 % higher in case of human and animal energy respectively in zone-II as compared to zone-I. The use of human and animal energy in puddling was in the range of 59.6-72.1 MJ/ha and 230.8-296.2 MJ/ha, respectively for all the categories of farms in zone-I. Tractor was not utilized by the farmers in both the zones due to small sized plots. Transplanting needed manual energy in the range of 203.6-215.6 MJ/ha in zone-I and 197.3-203.3 in zone-II. Haloding was the major operation performed by hill farmers in paddy, 3-4 weeks after sowing which needed the maximum human energy 50.3 MJ/ha and animal energy 149 MJ/ha in case of small farmers and minimum 36 MJ/ha and 104.5 MJ/ha for large category of farmers in zone-I. However, it was 89.3 MJ/ha and 258 MJ/ha for medium and 80.1 MJ/ha and 230.8 MJ/ha in case of marginal farmers in zone-II, respectively.

Weeding operation required the maximum human energy on small farms (155.7

MJ/ha) and minimum on large farms (133.1 MJ/ha) in zone-I whereas in zone-II, the maximum (163.3 MJ/ha) was for small farms and minimum 150.7 MJ/ha for large ones. Harvesting required 204-222 MJ/ha in zone-I and 209-216 in zone-II in case of all the farm groups. Threshing was done mostly by utilizing animate energy i.e. manual (71 MJ/ha) and animal (127 MJ/ha) in zone-I whereas zone-II utilized 70 MJ/ha and 158 MJ/ha, respectively. Transportation of produce required human energy in the range of 96.4-110.7 MJ/ha in zone-I and 97.8-112.6 in zone-II. Tractor energy was also utilized in the range of 38.7-231.9 MJ/ha in both the zones but animal energy was utilized for 4.5 MJ/ha only in zone-I.

It is also evident that the small farms utilized the maximum human energy of 1010.2 and 1045.3 MJ/ha followed by marginal (980.1 and 1026.2 MJ/ha), medium (972.1 and 1027.0 MJ/ha) and large farms (891.8 and 985.9 MJ/ha) in zone-I and II whereas the animal energy was utilized maximum (1092 and 1288 MJ/ha) with marginal farms followed by the small (1090 and 1252 MJ/ha), medium (1037 and 1196 MJ/ha) and large ones (699 and 983 MJ/ha). Mechanical energy was also utilized in the range of 403.8-436.6 MJ/ha in both the zones. Overall manual and animal energy utilization was 5 and 15 % higher in zone-II as compared to zone-I. The total energy consumption with all power sources for paddy crop was 2466 MJ/ha and 2670 MJ/ha in zone-I and zone-II, respectively which is quite low due to higher use of human and animal power in all the farm operations.

Table 2. Energy consumption (MJ/ha) with various power sources on different categories of farms for paddy in zone-I and zone-II

Operation	Zone- I					Zone- II				
	Marginal	Small	Medium	Large	Weighted Mean	Marginal	Small	Medium	Large	Weighted Mean
Seedbed Preparation										
Human	129.7	134.5	118.7	79.0	114.5	138.4	135.3	132.3	97.2	121.8
Animal	527.8	567.6	521.3	298.9	524.8	594.2	566.1	550.6	368.9	573.6
Tractor	289.9	230.0	483.2	1082.3	334.2	251.2	425.2	715.1	1275.6	382.5
Puddling										
Human	69.4	67.8	72.1	59.6	62.1	71.5	75.7	63.5	55.9	63.7
Animal	278.0	258.0	296.2	230.8	273.8	294.4	305.3	257.1	229.9	289.5
Transplanting										
Human	215.6	210.1	207.3	203.6	213.0	197.3	192.3	203.3	199.2	197.0
Haloding										
Human	43.1	50.3	39.9	36.0	43.9	80.1	85.8	89.3	82.1	82.4
Animal	139.9	149.0	116.3	104.5	137.5	230.8	240.8	258.0	234.4	235.9
Weeding										
Human	150.7	155.7	138.2	133.1	149.5	159.9	163.3	156.4	150.7	159.8
Harvesting										
Human	203.7	213.2	221.7	216.0	208.1	212.7	214.6	209.2	216.2	212.8
Threshing										
Human	71.5	75.2	67.6	53.8	71.0	67.8	71.5	75.2	72.0	69.5
Animal	141.7	112.7	98.1	58.1	127.3	168.1	139.9	130.8	149.9	157.5
Transportation										
Human	96.4	103.4	106.6	110.7	99.6	98.5	106.8	97.8	112.6	102.7
Animal	4.5	3.6	5.5	7.3	4.5	0.0	0.0	0.0	0.0	0.0
Tractor	77.3	116.0	173.9	231.9	102.4	0.0	38.7	77.3	96.6	21.3
Total Energy	2439	2447	2667	2906	2466	2565	2761	3016	3341	2670

Wheat

Maximum human energy use in seedbed preparation was in case of small (184 and 233.4 MJ/ha) because of greater use of animal energy and it was the minimum on large farms (52.5 and 108.3 MJ/ha) for zone-I and II and is presented in Table 3. Tractor use was the maximum on large farms (2660 MJ/ha) and animal energy use minimum (241.4 MJ/ha) for seedbed preparation. Mostly the farmers were practising broadcasting or dropping of seeds behind the plough for sowing of wheat. The maximum human energy use for sowing was on marginal farms (87.3 MJ/ha) followed by small (80.6 MJ/ha), medium (63.5 MJ/ha) and large farms (18.1 MJ/ha) in zone-I. The marginal and small farmers sowed wheat by dropping behind the plough whereas the large category of farmers broadcasted the seed due to shortage of animal power. Weeding was done manually and required the maximum human energy on medium farms (288 MJ/ha) followed by small

farms (282 MJ/ha) and the minimum in case of large farms (248 MJ/ha) for zone-I. Similarly harvesting operation needed the maximum human energy on medium farms (237 MJ/ha) followed by large farms (221 MJ/ha) and small farms (220 MJ/ha). Threshing was done by utilizing thresher with the help of tractor or diesel engine which needed manual energy to the tune of 45.3 MJ/ha and tractor energy 2013 MJ/ha in zone-I, whereas zone-II utilized 53 MJ/ha and 2942 MJ/ha. Human energy required for transportation of produce was 69.6 MJ/ha in zone-I and 81.9 MJ/ha in zone-II. Farmers utilized the tractor most of the time for transportation.

Table 3. Energy consumption (MJ/ha) with various power sources on different categories of farms for wheat in zone-I and zone-II

Operation	Zone- I					Zone- II				
	Marginal	Small	Medium	Large	Weighted Mean	Marginal	Small	Medium	Large	Weighted Mean
Seedbed Preparation										
Human	180.8	184.0	160.2	52.5	157.4	228.9	233.4	201.2	108.3	219.4
Animal	757.4	786.8	628.8	124.2	720.6	834.4	785.7	741.5	241.4	787.7
Tractor	668.8	512.4	1030.1	2402.7	712.9	504.2	1283.0	2059.0	2660.0	681.9
Sowing/ Planting										
Human	87.3	80.6	63.5	18.1	80.2	98.7	93.3	88.4	24.0	93.1
Animal	297.2	299.4	251.9	53.5	281.7	382.3	337.4	346.9	64.4	355.1
Tractor	252.1	224.1	464.7	666.6	287.8	120.3	292.5	246.4	649.0	193.2
Weeding										
Human	263.9	281.6	288.1	247.5	269.4	427.1	384.1	387.8	351.7	410.7
Fertilizer application										
Human	3.1	4.0	5.6	6.8	3.7	4.1	6.6	4.9	5.4	4.8
Harvesting										
Human	220.7	220.1	236.8	221.2	222.4	231.7	225.4	229.1	214.3	229.4
Threshing										
Human	40.3	51.3	59.4	55.2	45.3	49.5	55.1	65.0	61.4	52.9
Tractor	2013.1	1955.1	2149.2	1954.3	2013.0	3085.4	2765.7	2680.6	2334.7	2942.2
Transportation										
Human	73.7	76.3	49.4	30.4	69.6	85.4	98.6	49.1	38.1	81.9
Animal	11.2	12.4	0.0	0.0	9.7	0.0	0.0	0.0	0.0	0.0
Tractor	224.8	291.3	749.8	1004.7	330.3	0.0	181.3	246.4	541.1	86.9
Total Energy	5094	4979	6138	6838	5204	6052	6742	7346	7294	6139

The wheat production utilized the maximum human and animal energy of 898 MJ/ha and 1099 MJ/ha for small farmers followed by marginal (870 MJ/ha and 1066 MJ/ha), medium (863 MJ/ha and 881 MJ/ha) and large farmers (632 MJ/ha and 178 MJ/ha) whereas the mechanical energy utilization was maximum 6028 MJ/ha in case of large farmers followed by the medium (4394 MJ/ha), marginal (3159 MJ/ha) and small farmers (2983 MJ/ha) in zone-I. Similarly, in zone-II marginal farmers utilized the maximum of 1125 MJ/ha and 1217 MJ/ha followed by small (1097 MJ/ha and 1123 MJ/ha), medium (1026 MJ/ha and 1088 MJ/ha) and large farmers (803 MJ/ha and 3056 MJ/ha). Overall energy utilization was 22, 11 and 14 % higher in case of human, animal and tractor energy respectively in zone-II. It is clear that the animate energy utilization was decreasing from marginal to large farms but the mechanical energy was increasing in both the zones. It was also observed that the higher human energy per hectare was engaged to complete the agricultural operations for all the cereal crops. The total energy consumption for wheat crop was 5204 MJ/ha and 6139 MJ/ha in zone-I and zone-II, respectively.

Suggestion for future strategy

It is pertinent to add that due to difficult terrain, the problems of the hill farmers are more conspicuous than that of the farmers in the plain areas. Farm mechanization in the mountains is although a difficult task, yet not impossible. Thus the major issues which emerged from the present study have to be properly addressed while considering farm mechanization in the hills.

1. Supplementation of energy input to ensure timeliness of farm operations
2. Introduction of suitable power source like power tiller and allied equipment
3. Enhancing animal power utilization and use of crop-specific equipment
4. Design and development of cost-effective improved tools/equipment

5. Adequate farm mechanization for efficient utilization of inputs

Conclusion

Farm energy consumption in different agricultural operations with human, animal and tractor was 918 MJ/ha, 944 MJ/ha and 1478 MJ/ha for maize and 962 MJ/ha, 1068 MJ/ha and 437 MJ/ha for paddy crop in zone-I, respectively whereas in zone-II it was 1041 MJ/ha, 1055 MJ/ha and 1555 MJ/ha for maize and 1010 MJ/ha, 1257 MJ/ha and 404 MJ/ha for paddy crop. Similarly, wheat crop consumed 848 MJ/ha, 1012 MJ/ha and 3344 MJ/ha in zone-I and 1092 MJ/ha, 1143 MJ/ha and 3904 MJ/ha in zone-II with human, animal and tractor, respectively. Higher human power was engaged in all the crops for performing various operations with indigenous tools. The energy consumption was also observed higher in zone-II as compared to zone-I due to smaller size of plots. It clearly indicates that farm operations with above stated power source could not be performed timely and precisely with minimum drudgery.

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