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RESEARCH PAPER

Energy use pattern for chickpea production in sample village of Raichur region

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Abstract: Chickpea is an important grain legume crop in India. Among pulses, chickpea is one of the most important protein-rich cool season food legumes grown under rain fed conditions. Presently, there is no database available on energy requirements for chickpea production in Raichur region. Hence, a study was undertaken to work out energetics of implement package commonly used by the farmers. The results indicated that a total input energy required by the different categories of farmers MF, SF, MSF and LF were 4836.66, 5595.85, 5764.67 and 5721.01 MJ/ha for chickpea production. Seedbed preparation was the major energy consuming operation followed by irrigation and sowing in village. The total energy ratio of different categories of farmers MF, SF, MSF and LF were 3.23, 2.87, 2.77 and 2.96 respectively, while the specific energy and energy productivity for MF, SF, MSF and LF were 5.9, 6.62, 6.9 and 6.43 MJ/kg and 0.17, 0.15,0.14 and 0.16 kg/MJ respectively.

Key words: Chickpea, Energy ratio, Operation-wise energy requirement, Source-wise energy requirement, Specific energy requirement

Introduction

Energy has an influencing role in the development of key sectors of economic importance such as industry, transport and agriculture. This has motivated many researchers to focus their research on energy management. Energy has been a key input of agriculture since the age of subsistence agriculture. It is an established fact worldwide that agricultural production is positively correlated with energy input (Singh, 1999). Agriculture is both a producer and consumer of energy. It uses large quantities of locally available non-commercial energy, such as seed, manure and animate energy, as well as commercial energies, directly and indirectly, in the form of diesel, electricity, fertilizer, plant protection, chemical, irrigation water, machinery *etc.* Efficient use of these energies helps to achieve increased production and productivity and contributes to the profitability and competitiveness of agriculture sustainability in rural living (Singh *et al.,* 2002).

Efficient use of resources is one of the major assets of eco-efficient and sustainable production, in agriculture (De Jonge, 2004). Energy use is one of the key indicators for developing more sustainable agricultural practices (Streimikiene *et al.,* 2007) and efficient use of energy is one of the principal requirements of sustainable agriculture (Kizilaslan, 2009). It is important, therefore, to analyze cropping systems in energy terms and to evaluate alternative solutions, especially for arable crops, which account for more than half of the primary sector energy consumption (Sartori *et al.,* 2005).

Energy in agriculture is important in terms of crop production and agro processing for value addition (Karimi *et al.,* 2008). The relation between agriculture and energy is very close. Agriculture itself is an energy user and energy supplier in the form of bio-energy. At present, productivity and profitability of agriculture depends on energy consumption (Alam *et al.,* 2005).

Chickpea (*Cicer arietinum* L.) is an annual grain legume crop grown mainly for human consumption. It plays an important role in human nutrition as a source of protein, energy, fiber, vitamins and minerals for large population sectors in the developing world and is considered a healthy food in many developed countries (Abbo *et al.,* 2003; Anbessa *et al.,* 2007). Chickpea a cool season grain legume crop, is cultivated across the world including the Mediterranean basin, the near east, central and south Asia, east Africa, South America, North America and Australia. Major producing countries include India, Pakistan and Iran (Soltani *et al.,* 2006).

In India 91 per cent of coarse cereals, 91 per cent of pulses, 75 per cent of oilseeds and 65 per cent of cotton is being cultivated in rainfed regions. Among pulses, chickpea is one of the most important protein-rich cool season food legumes grown under rainfed conditions. India is the largest producer of chickpea accounting for 70.7 per cent of global production and 68 per cent of cultivated area (8.56 Mha) (Kiran and Chimmad, 2015) . However, India remains as main chickpea importing country accounting for 25.7 per cent of global (Kassie *et al.,* 2009).

Energy requirements for various farm operations have been recognized as an essential data to correctly match the agricultural implements and other power sources. The database on various implement packages for various crop production systems have been worked out for various regions. Presently there is no database available on energy requirement for chickpea production in Raichur region. Lack of such information inhibits systematic economic evaluation of implement package used for chickpea production. Hence, there is a need to work out energy use pattern for chickpea production in sample village of Raichur region.

Material and methods

The village Kalmala is located about 19 km to the west of Raichur city at a latitude of 16°11'52" N and 77°12'22" E longitude. The altitude is about 404 m above Sea level and average rainfall is about 760 mm, which is mainly concentrated in the months of July, August and September. The climate is moderate, normally the temperature ranges between 25 to 40 °C.

The energy utilization of implement package by the different categories of farmers of chickpea production in the selected village was collected through personal interviews, observations and measurements wherever necessary (Appendix-II). The data collected for selected operations were verified by calculating the actual energy requirements by actually measuring the time requirement for field operations among farms belonging to all categories of the farmers who were growing chickpea as their major crop.

The energy used for a particular field operation was calculated as the sum of human, bullock, tractor and mechanical and/or electrical energy consumed for that operation. The energy expended for each individual farm operation was calculated as suggested by Anon. (1992).

Effective field capacity of the machine C_e= ha/h

No. of hours required to cover one ha, t = $1/_{Ce,}$ h

No. of male labours required = N_1

No. of female labours required = N_2

Total human-hr required $t_1 = N_1 t + N_2 t$

No. of animal pairs required = N_3

No. of animal pair-hr required $t_2 = N_3 \times t$

No. of farm machines used = N_4

Total machine-hr required $t_3 = N_4 \times t$

Total human energy spent $E_1 = N_1 \times t \times 1.96 + N_2 \times t \times 1.57$, MJ/ha

Total animal energy spent $E_2 = N_3 \times t \times 10.10$, MJ/ ha

Let, the weight of the farm machine = W, kg

Annual use of farm machine = X, hr

Total life in years =Y, Total life in hours = X ×Y

Weight of the machine per unit hour of operation

$W_1 = W/X \times Y$

Total machine energy spent $E_3 = W_1 \times t \times 62.7$, MJ/ha

weight of the tractor per unit hour of operation

$W_2 = W/X \times Y$

Total tractor energy spent $E_4 = W_2 \times t \times 68.40$, MJ/ha

Total energy used for the particular operation,

$E = E_1 + E_2 + E_3 + E_4$, MJ/ha

Source-wise energy use was calculated based on the energy spent by different direct and indirect sources using energy coefficients given in Table 1. The total input energy was calculated by adding the direct and indirect energy. The output energy was calculated for both grain and haulm using the energy coefficients (Table 1). The energy ratio for both pod and haulm was calculated by dividing the output energy obtained from grain and haulm by total input energy respectively. Specific energy requirement was calculated by dividing the total input energy for chickpea production (MJ/ha) by the pod yield (kg/ha).

Table 1. Equivalents for direct and indirect sources of energy

Particulars	Units	Equivalentenergy, MJ	Remarks
A. Inputs:			
1. human labour			
a) Adult man	Man-hour	1.96	1 Adult woman = 0.8 Adult man
b) Adult woman	Woman-hour	1.57	
2. Bullocks Medium	Pair-hour	10.10	Body weight 352-450 kg
3. Electricity	kWh	11.93	
4. Machinery			Distribute the weight of machinery equally over the total span of the machinery (in hours). Find the use of machinery (in hours) for particular operation.
a) Tractor	kg	68.40	
b) Electric motor	kg	64.80	
c) Farm Machinery	kg	62.70	
5. Fuel			
a) Diesel	l	56.31	
b) Petrol	l	48.23	
6. Fertilizers	kg	60.60	Estimate the quantity of nitrogen, P_2O_5 and K_2O in the chemical fertilizer. Then compute the amount of energy input from chemical fertilizer.
Nitrogen	kg	11.10	
P_2O_5	kg	6.70	
K_2O			
Pesticide	kg	120	
7. Seed	kg	14.7	
8. Water	m^3	0.63	
B. outputs:			
1. Grain2. Haulm	kg kg	14.712.5	

Sources: Mittal and Dhawan (1988), Payman Salami (2010) and Patil *et al.* (2016)

Results and discussion

The energy spent for different farm operations *viz.,* seedbed preparation, sowing, fertilizer application, irrigation, intercultivation/

weeding, harvesting and threshing in different categories of farmers are presented in Table 2.

The maximum of 1204.95 MJ/ha of energy was used by small farmers and a minimum of 911.20 MJ/ha by large farmers for seedbed preparation. For sowing and fertilizer application, maximum of 560.25 MJ/ha of energy was used by marginal farmers and a minimum of 423.23 MJ/ha by large farmers. For irrigation water, maximum of 653.33 MJ/ha of energy was used by large farmers and a minimum of 516.33 MJ/ha by marginal farmers.

The maximum of 380.35 MJ/ha of energy was used by marginal farmers and a minimum of 298.02 MJ/ha by large farmers for inter-cultivation. The maximum of 69.23 MJ/ha of energy was used by medium sized farmers and a minimum of 56.23 MJ/ha by marginal farmers for harvesting the crop. The energy consumed for threshing the crop by different categories of farmers varied from 115.22 to 416.69 MJ/ha. The maximum of 416.69 MJ/ha of energy was used by large farmers and a minimum of 115.22 MJ/ha by marginal farmers.

Energy supplied through different direct and indirect energy sources *viz*., human, animal electricity, seed, fertilizer and machinery for raising groundnut in different treatments are presented in Table 3. The maximum of 572.01 MJ/ha of energy was used through human labours among marginal farmers and a minimum of 429.78 MJ/ha by large farmers. Animal energy input for raising chickpea by different categories of farmers varied from 33.02 to 34.45 MJ/ha. The tractor energy used was maximum (150.48MJ/ha) among small farmers and a minimum of 118.33 MJ/ha by marginal farmers for chickpea production. The fuel energy used was maximum (1491.10MJ/ha) among medium farmers and a minimum of 1291.19 MJ/ha by medium farmers.

The maximum of 1323 MJ/ha of energy was supplied through seed among small farmers and minimum of 1029 MJ/ha by marginal farmers. The maximum of 1719.73 MJ/ha of energy was supplied through fertilizer among large farmers and minimum of 1143.34 MJ/ha by marginal farmers. The maximum of 196.28 MJ/ha of energy was supplied through machinery among large farmers and a minimum of 96.38 MJ/ha by marginal farmers.

The total energy spent for field operations, energy supplied through seed and fertilizers are presented in Table 4. Also, the grain and haulm yield, output energy, energy ratio and specific energy in different treatments are presented in Table 4. The maximum pod yield of 889 kg/ha was observed in large farm

Table 2. Operation-wise energy input by farmers for chickpea production

Farm Operation	Operation-wise Energy input, MJ/ha				Mean
	MF	SF	MSF	LF	
Seedbed Preparation	1024.1 (38.61)	1204.95 (41.71)	923.5 (33.49)	911.2 (32.92)	1015.93 (36.72)
Sowing & Fertilizer Application	560.25 (21.1)	482.5 (16.71)	464.12 (16.83)	423.23 (15.30)	482.52 (17.44)
Irrigation	516.33 (19.46)	632.26 (21.90)	586.33 (21.26)	653.33 (23.72)	597.06 (2158)
Inter-cultivation	380.35 (14.33)	365.25 (12.65)	338.52 (12.27)	298.02 (10.77)	345.55 (12.49)
Harvesting	56.23 (2.1)	63.5 (1.30)	69.23 (2.51)	64.95 (2.35)	63.47 (2.29)
Threshing	115.22 (4.34)	138.36 (2.81)	376.19 (13.64)	416.69 (15.05)	261.61 (9.46)
	2652.38 (100)	2886.79 (100)	2757.64 (100)	2767.42 (100)	2766.14 (100)

Table 3. Source-wise energy input among different categories of farmers for chick pea production

Source of Energy	Farming category				Mean
	MF	SF	MSF	LF	
Direct Energy, MJ/ha					
Man	50.65 (1.02)	55.11 (0.98)	69.08 (1.2)	59.01 (1.03)	58.46(1.05)
Woman	499.65 (10.12)	516.0 (9.22)	463.41 (8.03)	370.77 (6.48)	462.45(8.46)
Tractor	138.85 (2.81)	150.48 (2.69)	122.43 (2.12)	118.33 (2.06)	132.52(2.42)
Bullock	34.45 (0.7)	33.02 (0.59)	-	-	16.87(0.32)
Diesel	1291.19 (26.16)	1379.03 (24.64)	1491.10 (25.86)	1484.33 (25.95)	1411.41(25.65)
Electricity	494.61 (10.02)	605.69 (10.82)	561.90 (9.74)	629.55 (11.0)	572.94 (10.40)
A) Total Direct Energy, MJ/ha	2509.4 (50.83)	2739.33 (48.95)	2707.92 (46.97)	2661.99 (46.53)	2654.65(48.3)
In-Direct Energy, MJ/ha					
Seed	1029 (20.84)	1323 (23.64)	1176 (20.40)	1176 (20.55)	1176(21.35)
Fertilizer					
N	778.71 (15.77)	934.45 (16.70)	1171.39 (20.32)	1171.39 (20.48)	1013.98 (18.32)
P	364.63 (7.39)	437.56 (7.82)	548.34 (9.51)	548.34 (9.58)	474.71 (8.58)
Machinery	142.32 (2.88)	146.09 (2.61)	146.72 (2.54)	147.35 (2.58)	145.62 (2.65)
Water	12.6 (0.26)	15.42 (0.28)	14.30 (0.25)	15.94 (0.28)	14.56 (0.27)
B) Total In-Direct Energy, MJ/ha	2327.26 (48.12)	2856.52 (51.04)	3056.75 (53.02)	3059.02 (53.46)	2824.88 (51.17)
Total Input Energy (A+B), MJ/ha	4836.66 (100)	5595.85 (100)	5764.67 (100)	5721.01 (100)	5504.54 (100)
Renewable Energy, MJ/ha	1626.35 (29.83)	1942.55 (32.72)	1722.79 (28.62)	1621.72 (29.44)	1728.35 (31.40)
Non-Renewable Energy, MJ/ha	3310.31 (70.71)	3653.3 (67.28)	4041.88 (71.38)	4099.29 (70.56)	3776.2 (68.60)

Table 4. Input energy, yield, output energy, energy ratio, specific energy and energy productivity

Parameters	Farming category				Mean
	MF	SF	MSF	LF	
Input energy (MJ/ha)					
Field operations	2652.38	2886.79	2757.64	2767.42	2766.05
Seed	1029	1323	1176	1176	1176
Fertilizers	1143.34	1372.01	1719	1719.73	1488.52
Water	12.6	15.46	14.30	15.94	14.57
Total input energy (MJ/ha)	4836.66	5595.85	5764.67	5721.01	5479.55
Yield (kg/ha)					
Grain yield	820	845	836	889	3390
Stover yield	200	206.07	203.90	216.82	826.79
Output energy (MJ/ha)					
Grain	12054	12421.5	12289.2	13068.3	12458.25
Stover	3600	3709.26	3670.2	3902.76	3720.55
Total output energy (MJ/ha)	15654	16130.76	15959.4	16971.06	16178.80
Energy – ratio					
Grain	2.49	2.22	2.13	2.28	2.60
Stover	0.74	0.66	0.64	0.68	0.67
Total energy-ratio	3.23	2.87	2.77	2.96	2.96
Specific energy (MJ/kg)	5.9	6.62	6.9	6.43	6.5
Energy productivity (kg/MJ)	0.17	0.15	0.14	0.16	0.15

category and a minimum of 820 kg/ha in marginal category. The maximum haulm yield of 216.82 kg/ha was observed in large farm category and a minimum of 200 kg/ha in marginal category.

The maximum output energy of 13068.3 MJ/ha from grain obtained among large farmers and a minimum of 12054 MJ/ha was by marginal farmers. The maximum output energy of 3902.76 MJ/ha from haulm obtained among large farmers and a minimum of 3600 MJ/ha was by marginal farmers. The maximum total energy ratio of 3.23 was obtained from both grain and haulm among marginal farmers and a minimum of 2.77among medium farmers. The specific energy required for raising chickpea was maximum (6.90 MJ/kg) among medium farmers and a minimum of 5.9 MJ/kg among marginal farmers.

Conclusions

Seedbed preparation was the major energy consuming operation followed by irrigation and sowing in Kalmala village. Inter-cultivation was labour intensive operation which accounted for 9 to 14 per cent of total operational energy for chickpea production. Energy ratio and specific energy requirement (MJ/kg) of 2.96 and 6.5 MJ/kg were obtained by farmers in Kalmala village.

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