Energy Consumption and Cost Auditing for Cultivation of Black Gram Crop in Terrace Condition - A Case Study in Sikkim

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ABSTRACT

The energy input is considered as one of the most important yardsticks for the productivity of land. This paper deals with auditing of energy use for black gram crop considering the inputs like seed, organic manure, bio-pesticides and various farm operations carried out by bullock operated equipment. The cost of cultivation, returns and profits under black gram crop were worked out. The energy requirement for cultivation of black gram was also worked out under zero tillage sowing condition on terraces which required lesser energy and cost of cultivation as compared to traditional cultivation system. The total energy consumption values for traditional cultivation, improved cultivation system with normal tillage and zero tillage based improved system were 9088, 9184 and 3421 MJ/ha respectively. The maximum energy consumption was 9184 MJ/ha for improved cultivation system with normal tillage which was 62.75% higher than total energy consumption in the improved method with zero tillage condition. The cost of cultivation for improved cultivation system with zero tillage, improved cultivation system with normal tillage and traditional cultivation system were Rs. 8,669/ha, Rs. 15,365/ha and Rs. 23,780/ha respectively. The cost of cultivation in traditional cultivation method was 63.54% higher than improved method with zero tillage condition. The improved cultivation method with normal tillage saved 35.38% in cost of cultivation as compared to traditional method of black gram cultivation. The returns from black gram cultivation, including stover cost in improved equipment system with normal tillage, improved equipment system zero tillage and traditional cultivation system were worked as Rs. 54,288/ha, Rs. 52,078/ha and Rs. 51,132/ha respectively. The Benefit-Cost ratio for improved equipment system with normal tillage, improved equipment system with zero tillage and traditional cultivation system were 3.53, 6.0 and 2.15 respectively.

Key words: *Zero-tillage, Energy consumption, Benefit-cost ratio, Black gram, Tillage.*

INTRODUCTION

Current package of practices of crop production involves various sources of energy - some are locally available non-commercial while others are commercial such as diesel and electricity, certified seeds and planting materials, fertilizers, pesticides and farm machinery. In the world, pulses are grown in 72.3 million ha by 171 countries. This area provides about 64.4 million tonnes of pulses with a productivity of 890 kg/ha. The highest area is contributed by India (35 %) followed by Niger (7), Myanmar (5.33), Brazil (5.29) and Nigeria (4.44). India accounts for 27% of global pulses production. About 87% of pulses cultivation in India is rainfed; grown mostly in poor and marginal lands with minimal inputs and very little mechanization. The production of pulses is 17.2 million in the country (2014-15). To enhance overall production of pulses, there is an urgent need to bring in 3-4 million hectares of additional area under pulses. The black gram crop is grown in cropping systems as a mixed crop, catch crop or sequential crop. In India, black gram is sown in 3.29 million ha with a total production of 1.60 million tonnes. The leading states producing black gram are Andhra Pradesh, Odisha, Bihar, Madhya Pradesh, Maharashtra, Uttar Pradesh, West Bengal, Haryana, Tamilnadu and Karnataka. Andhra Pradesh leads with the highest productivity followed by Orissa. *Kalodal* or *Panhelo* are extensively cultivated in the dry belts of South and West districts of Sikkim. In Sikkim, total area under black gram is 5960 ha and the productivity is 880 kg/ha. The maximum area of black gram crop (2610 ha) is in West Sikkim district with total production of 2410 tonnes. Proper management of various operations in the production system and judicious use of inputs can contribute towards reduction of energy input. The objective of study was to work out the energy requirement for cultivation of black gram in improved methods (zero tillage and normal tillage cultivation) and their comparison over traditional method (traditional plough, broadcasting followed by planking with *dande*). For interculture, harvesting and threshing improved equipment were included which were twin wheel hoe, improved sickle and small power thresher for ensuring time and labour savings. The energy and cost of cultivation of black gram were lesser on zero tillage sown terraces as compared to normal sowing by tool frame attached sowing equipment.

Bohra *et al*. (1990) conducted study to evaluate the energy input, cost, yield using bullock and power tiller operated systems. In bullock operated system, output-input ratio was 8:13 and net profit was Rs 2900/ha. A single row seed drill (weight: 19.8 kg) was evaluated for black gram (variety: Parvati) at OUAT, Bhubaneshwar. The effective field capacity and field efficiency were 0.036 ha/h and 66.85% respectively. There were savings of 18.74 man-days/ha in labour and Rs 3320/ha in cost of operation over traditional sowing practice (Anonymous 2011). A single row light weight animal drawn zero till seed drill (overall dimensions : 620 x 230 x870 mm, weight : 13 kg) with inverted T type furrow opener and fluted roller type seed metering mechanism was developed and tested by GBPUAT, Pantnagar centre of AICRP on Utilization of Animal Energy. The relief and rake angles in inverted 'T' type furrow opener were 20 and 5 degree respectively. The effective field capacity and field efficiency were 0.045 ha/h and 81.5% respectively (Anonymous, 2009).

Islam *et al.* (2001) studied bullock farming system for pulses and found 17.4% higher energy input and energy ratio of 2.26 in bullock owned system than power tiller farming system. Koocheki *et al.* (2011) evaluated pulses production systems in terms of energy use efficiency and economical analysis. The energy use efficiency ranged from 1.21 to 1.81. The total energy requirements for production of pulses were 14115 and 23666 MJ/ha under rainfed and irrigated conditions. Mittal *et al*. (1985) analysed the work on energy requirements in agricultural sector. They concluded that irrigated farms required an additional amount of 375.83 MJ/ha of bullock energy and 770.46 MJ/ha of human energy as compared to rainfed farms.

Black gram varieties, 'T9' registered higher net return of Rs. 19250/ha, with B: C ratio of 4.24 followed by 'TMV1' registering the net return of Rs. 19150/ha with B: C ratio of 4.25. Higher net returns and B:C ratio of 'T9' and 'TMV1' were attributed to higher grain yield recorded by these varieties. Energetic analysis of black gram indicated that input energy of 748.10 MJ/ha was consumed by the crop. 'T9' variety of black gram recorded higher output energy of 13965 MJ/ha followed by 'TMV1'. Specific energy was lower for 'T9' and 'TMV1' (0.78 and 0.79 MJ/kg) indicating that less energy was required by 'T9' and 'TMV1' varieties to produce one kg of grain. Better performance of 'T9' and 'TMV1' varieties in terms of energy were attributed through production of more economic biomass (Ahmed *et al.,* 2014).

MATERIALS AND METHODS

The animal based cultivation systems in terraces were evaluated for black gram in order to achieve the timeliness and saving of inputs for ensuring more yield of black gram crop by All India Coordinated Research Project on Utilization of Animal Energy located at College of Agricultural Engineering and Technology and Post Harvest Technology, Ranipool in Sikkim. For the study, black gram crop was raised in terrace condition at Samlik village in Gangtok (East Sikkim) in 0.8 hectare land. In traditional cultivation method of black gram, traditional plough, leveller (*Dande*), broadcasting of seeds, local *khurpa,* local sickle and threshing by wooden stick were used with use of farm yard manure and higher seed rate during test trial. Under bullock farming system animal drawn improved wedge plough, improved clod crusher cum leveller, improved tool frame with seeding attachment, animal drawn two row improved zero till seed drill, manual wheel hoe, manual knapsack sprayer, improved sickle and small power thresher were used for carrying out various farm operations in improved cultivation systems. The inputs like farm yard manure, seeds and bio-pesticide were used as per recommended agronomic practices for the hill region. Field trials of tool frame attached seeding attachment and two row seed drill were conducted at 365 mm row spacing using seed rate of 20 kg/ha. The traditional sowing of black gram was performed with higher seed rate (25 kg/ha). Farm Yard Manure was applied @ 2 t/ha in improved cultivation system with normal tillage and traditional cultivation system. Improved cultivation system with zero tillage had no farm yard manure and intercultural operation. The data were recorded for the use of human and animal power, electrical energy and equipment used for carrying out various farm operations. While recording these data, the time spent on any major breakdowns, if any was excluded. However, the time for minor adjustments was included in the operation time. The data presented for crop yield are for sundried cleaned products.

The energy audit in the cultivation of crop was done to study the intake and energy generated by the crop. The ratio was worked out by dividing the total energy generated from the main product and by-product by the total energy used for raising a crop in the unit area. For this auditing the energy equivalence of various energy inputs and outputs as suggested by Mittal and Dhawan (1988) were used which included human, bullocks pair, electricity, traditional, seed, farm yard manure, biopesticide, crop residue, traditional and and improved equipment etc. The energy required for the farm operation was determined by calculating the total energy input included energy for bullock, machinery and human. Energy analysis were taken into account for all forms of energy input to the production system and energy output from the system and established energy relationship for understanding the energy conversion process.

Specific energy (MJ/kg) was used in energy analysis to express the quantity of energy invested to produce unit quantity of the product. Energy productivity which measured the quantity of product produced per unit of input energy (kg/MJ) was the inverse of specific energy. Energy ratio is ratio of output energy (MJ) and input energy (MJ). The cost of operation of various equipment was calculated as per the standard procedure suggested by Bureau of Indian Standard and the same was used for computing the cost of cultivation. The cost of using bullock power was worked out as per the recommendations of AICRP on UAE. For cost calculation, the unit price of bullock drawn improved wedge plough, improved clod crusher cum leveller, two row improved zero till seed drill, improved tool frame with seeding attachment, twin wheel hoe, improved sickle, electric motor and small power thresher (1.5 kW capacity)) were taken as Rs 1000, 2500, 6500, 4500, 350, 60, 12000 and Rs. 30000 respectively. The initial cost of pair of bullocks (Local breed –*Siri*) was taken as Rs. 30000/-. The prices of black gram and its straw have been taken as Rs 6000/- and Rs 200 per quintal respectively.

RESULTS AND DISCUSSION

Operation-wise analysis for black gram crop showed that the normal tillage based improved equipment system required three operations for seedbed preparation (improved wing plough-02, improved clod crusher cum leveler-01) while traditional equipment system required five operations (traditional plough-3 and traditional leveller known as *Dande* -02) to achieve good quality of operation. The grain yield of black gram crop was 8.6 q/ha and 8.25 q/ha and 8.10 q/ha for improved equipment with normal tillage, zero tillage and traditional equipment systems respectively. The higher yields of the crop under improved systems were possibly due to the timeliness of critical operation with mechanization. Under improved system with normal tillage and zero tillage stover (straw and stalks) yields were 13.44 and 12.89 q/ha respectively. For traditional cultivation system yield of stover was lower (12.66 q/ha).The zero tillage based improved system for cultivation of black gram saved 71.05% direct energy over traditional method. The improved method with normal tillage had saving of 35.88% in direct energy than traditional cultivation system. The total energy consumption values for traditional cultivation, improved cultivation system with normal tillage and zero tillage based improved system were 9087.76, 9184.53 and 3420.90 MJ/ha respectively (Table1).

The maximum energy was 9184.53 MJ/ha for cultivation with zero tillage, improved cultivation system with normal tillage and traditional cultivation system were Rs. 8,669/ha, Rs. 15,365/ha and Rs. 23,780/ha respectively. The cost of cultivation in improved cultivation system with normal tillage which was 62.75% higher than total energy consumption in the improved method with zero tillage condition. The energy input for improved method with zero tillage condition was 62.35% less than traditional cultivation method. The maximum energy output-input ratio was 3.54 which were for improved method with zero tillage condition. The improved cultivation systems with normal tillage and zero tillage gave energy output-input ratio of 1.37 and 1.31 respectively. The specific energy was minimum (4.14 MJ/kg) for improved cultivation method with zero tillage condition and maximum (11.21 MJ/kg) for traditional cultivation method. Energy productivity was found maximum (0.24 kg/MJ) for improved method of cultivation in zero tillage condition. The cost of cultivation for improved traditional cultivation method was 63.54% higher than improved method with zero tillage condition. The improved cultivation method with normal tillage saved 35.38% in cost of cultivation as compared to traditional method of black gram cultivation. There was a saving of 43.57% in cost of cultivation using improved method with zero tillage condition as compared to improved cultivation method with normal tillage. The return for cultivation of black gram in improved equipment system with normal tillage, improved equipment system zero tillage and traditional cultivation system were Rs 51600/ha, Rs 49500/ha and Rs 48600/ha respectively. The returns from black gram cultivation, including stover cost in improved equipment system with normal tillage, improved equipment system zero tillage and traditional cultivation system were worked as

Table 1: Energy input for cultivation of black gram in traditional and improved methods under bullock farming system

Operation	Direct energy, MJ/ha			Indirect energy, MJ/ha		Total energy, MJ/ha
	Traditional cultivation method	Improved method with zero tillage condition	Improved method with normal tillage	Equipment	Other indirect energy,	
Ploughing	889.36	-	762.23	815.1	1500 (FYM)	9087.76*
Leveling	351.25	-	208.18			
Sowing	20.41	246.31	128.10		294^{sm} Seeds 367.5^{sd} Seeds	
Interculture	392	-	24.5	282.15		
Plant protection	294	39.2	39.2	1316.7	1065.9 (Biopesticide)	3420.9** 9184.53***
Harvesting	392	313.6	313.6	21.94	-	
Threshing	156.8 (Manual)	123.25 (Thresher)	124.38 (Thresher)			
Total	2495.82	722.36	1600.19	4724.44	3090.15* 1359.9** 4082.55***	

**Traditional system with normal tillage,*
*** Improved system with zero tillage,*
****Improved system with normal tillage, sm - Seed metered, sd - Seed broadcasted*

Table 2: Cost economics per hectare for sowing black gram under bullock farming system

(A) Cost	Improved equipment system with normal tillage Cost, Rs./ha	Improved practice system with zero tillage Cost, Rs./ha	Traditional cultivation system with normal tillage Cost, Rs./ha
Seedbed preparation	2632	-	3222
Sowing	320	615	208
Interculture	490	-	4000
Plant protection	400	400	3000
Harvesting, handling and transportation	3200	3200	4000
Threshing	473	454	1600
Farm yard manure	4000	-	4000
Seed	3000	3000	3750
Bio-pesticide	850	1000	-
Total	**15365**	**8669**	**23780**
(B) Returns			
Grain	51600	49500	48600
Straw	2688	2578	2532
Total	**54288**	**52078**	**51132**

Rs. 54,288/ha, Rs. 52,078/ha and Rs. 51,132/ha respectively (Table 2). The net returns from black gram cultivation, including Stover cost in improved equipment system with normal tillage, improved equipment system with zero tillage and traditional cultivation system were Rs. 38,923ha, Rs. 43,409/ha and Rs. 27,352/ha respectively.

The maximum net profit (Rs. 43,409/ha) was in improved tillage cultivation in zero tillage condition and minimum net profit (Rs. 27,352/ha) was found in traditional system. The net profit in improved cultivation system in zero tillage condition gave 10.33% higher as compared to improved equipment system with normal tillage. The net profit values for improved equipment system with normal tillage, improved equipment system with zero tillage and traditional cultivation system were 71.69%, 83.35% and 53.49% respectively. The improved equipment system with normal tillage resulted 29.72% higher net profit as compared to traditional cultivation system. The net profit was 37% less in traditional cultivation system as compared to improved cultivation system for zero tillage condition. The Benefit-Cost ratio for improved equipment system with normal tillage, improved equipment system with zero tillage and traditional cultivation system were 3.53, 6.0 and 2.15 respectively.

CONCLUSIONS

The total energy consumption values for traditional cultivation , improved cultivation system with normal tillage and zero tillage based improved system were 9087.76, 9184.53 and 3420.90 MJ/ha respectively. The maximum energy output-input ratio was 3.54 for improved method with zero tillage condition. The specific energy was minimum (4.14 MJ/kg) for improved cultivation method with zero tillage condition and maximum (11.21 MJ/kg) for traditional cultivation method. The cost of cultivation in traditional cultivation method was 63.54% higher than improved method with zero tillage condition and the improved cultivation method with normal tillage saved 35.38% in cost of cultivation as compared to traditional method of black gram cultivation. The maximum net profit (Rs 43409/ha) was in improved tillage cultivation with zero tillage condition and minimum net profit (Rs 27352/ha) was found in traditional system. The Benefit-Cost ratio for improved equipment system with normal tillage, improved equipment system with zero tillage and traditional cultivation system were 3.53, 6 and 2.15 respectively.

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