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Energy Evaluation of Kala Zeera (*Bunium persicum* Bios.) cultivation under Gurez valley of Temperate Kashmir

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ABSTRACT

Energy being the critical aspect of agricultural production, the modern agricultural system takes into account all the agricultural operations in terms of energy input and the yield obtained as energy output. It is this energy balance equation which describes the viability of a system. Depending upon the variation in energy consumption among various agro–climatic and environmental conditions and the output therein, a wide variation exists in the viability of these systems. In the present study, the energy balance in Kala zeera management system was taken into consideration. Data and information were collected and different energy use efficiency indices were calculated. Amon the production practices in Kala zeera cultivation, consumed root tubers for sowing were the most energy consuming input (43.32%) followed by diesel fuel (20.28 %) and Nitrogen (18.30). the total energy input could be classified in Kala zeera fields as direct (10.80%), indirect (25.60%), renewable (43.3%) and non-renewable (20.27%). Overall in view of sustainability, it is recommended that major input consumptive processes shall be optimized to increase energy use efficiency.

Key words: Kala zeera , Energy management, Energy Use Efficiency

INTRODUCTION

Indian agriculture provides employment to 70% of the population generates 40% of the national income and consumes about 10% of the commercial forms of energy. Agriculture is an important sector for production of food and raw material. All the agriculture operations require energy in one form or another like human labour, animal power, fertilizers, machinery, chemicals, fertilizers etc. Energy use in agricultural production has become more intensive due to use of fossil fuel, chemical fertilizers, pesticides, machinery, and electricity to provide substantial increases in food production. Efficient use of energy is one of the principle requirements of sustainable agriculture. Many researchers have studied energy and economic analysis to determine the energy efficiency of plant production such as sugarcane in morocco (Singh *et al.,* 2003). Apple and Cucumber in Iran (Alam *et al.,* 2005). Similarly Kala zeera requires application of animate /inanimate (bullock, man power/ tractors and tillers) forms of energy at different stages. Nutrients both through FYM and chemical fertilizers are provided. For checking any disease, insect – pest, weeds, chemicals and manpower and ultimately energy is required to fulfill all the operations necessary for crop growth and yield. To meet the basic food needs of our expanding human population, a productive sustainable agriculture must become a major priority; generally in order to obtain higher productivity. Farmers in general use their resources in excess and inefficiently particularly when these are priced low or free or are available in plenty under Gurez valley conditions of temperate Kashmir. So the present study deals with input – output energy use in Kala zeera with the aim to determine the total amount of energy utilized and the make decisions with regard to energy management of Kala zeera production under temperate conditions.

MATERIALS AND METHODS

The survey was carried out in Gurez valley of temperate Kashmir. Data were collected from Kala Zeera farmers by using face to face questionnaire. As well as information obtained by surveys of related organizations. A random sampling method was used. The sample size was calculated using equation 1.

$$n = \frac{N \times S^2}{(N-1)\,S2x + S2} \qquad \text{[Eq.1]}$$

Where n is the required sample size, N is population size, S is standard deviation, Sx is standard deviation of sample mean (Sx= d/z), d is permissible error in the sample size, was defined to be 5 % of the mean for a 95 % confidence interval and z is the reliability coefficient (1.96 which represents 95 % reliability). Based on these calculations a size of 35 was considered as sampling size in Kala zeera fields. The energy source can be classified in a number of ways based on the nature of their transaction, also the energy sources are classified based on animate and inanimate characteristics. On the basis of source, the energy can be classified as direct and indirect energy.

Direct source of energy are those forms that release the energy directly – like man power, bullocks, stationary and mobile mechanical or electric power units viz. diesel engines, electric motor, power tiller and tractors. The direct energy may be further classified as renewable and non-renewable sources of energy depending upon their replenishment. Renewable

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direct sources of energy include the energy sources which are direct in natural but can be subsequently replenished. The energies which may fall in this group are human beings, animals, solar and wind energy, fuel wood, agricultural wastes, etc. Non-renewable direct sources of energy are the direct energy sources which are not renewable at least in near further say next 100 years are classified. Coal and fossil fuels exemplify non–renewable direct source of energy. The indirect sources of energy are those which do not release energy directly but release it by conversion process. Some energy is invested in producing indirect sources of energy. Seed, manures, FYM, chemicals, fertilizers and machinery can be classified as indirect sources of energy. The energetic efficiency of the agriculture system has been evaluated by the energy ratio between output and input. Human labour, Machinery, diesel oil, fertilizers, pesticides and seed amounts and output yield values of Kala zeera production system have been used to estimate the energy ratio. Energy equivalents revealed in Table 1were used for estimation.

Table 1 :Energy equivalents for direct and indirect sources of energy.

Items	Quantity per unit area (ha)	Energy equivalent (MJ/ Unit)
INPUT Energy		
Inputs		
1. Human Labour	hr	1.95
2. Machinery	hr	62.7
3. Diesel Fuel	l	50.23
4. Nitrogen (kg)	Kg	75.46
5. Phosphate; P_2O_5 (kg)	Kg	13.07
6. Potash ; K_2O (kg)	Kg	11.15
7. Herbicide (kg or L)	Kg or l	356.29
8. Fungicide (kg or L)	Kg or l	92.01
9. Propagules/ Seed (kg)	kg	14.97
OUTPUT		
10.Kala Zeera Seed Yield	kg	21.0
11.Kala zeera straw Yield	kg	18.4

The mechanical energy was computed on the basis of total fuel consumption (l/ha) in different operations. Therefore energy consumed as calculated, using conversion factor (1 l diesel = 56.31 MJ) and expressed MJ/ha. Basic information on energy inputs and Kala zeera yields were transferred into excel spread sheets and analysed. Based on energy equivalents of the input and outputs (Table 1), the energy ratio or Energy Use efficiency, Energy productivity and the specific energy was calculated.

$$\text{Energy Use Efficiency} = \frac{\text{Energy Output (MJ ha}^{-1})}{\text{Energy Input (MJ ha}^{-1})} \quad \text{[Eq.2]}$$

$$\text{Specific Energy} = \frac{\text{Energy Input (MJ ha}^{-1})}{\text{Crops Output (t ha}^{-1})} \quad \text{[Eq.3]}$$

$$\text{Energy Productivity} = \frac{\text{Crops Output (kg ha}^{-1})}{\text{Energy Input (MJ ha}^{-1})} \quad \text{[Eq.4]}$$

$$\text{Energy intensiveness} = \frac{\text{Energy Input (MJ ha}^{-1})}{\text{Cost of cultivation (Rs/ha)}} \quad \text{[Eq.5]}$$

$$\text{Net energy} = \frac{\text{Energy Output (MJ ha}^{-1})}{\text{Energy Output (MJ ha}^{-1})} \quad \text{[Eq.6]}$$

RESULTS AND DISCUSSION

Cost of Cultivation

The maximum cost of Kala zeera cultivation isits planting material called tuber (Vegetative propagules), as it is often collected from forest area. On average it costs Rs 1.5/tuber (More than 2 g weight). But as it is perennial crop, so these planted tubers give this crop for six years. So the cost of tuber plantation is divided into six years, Irrespective of method of preparation of field, the total cost of Kala Zeera cultivation in Gurez valley is Rs1, 42, 448 where Gross income observed is Rs 4, 50, 000 with a net profit of Rs.3,07,552 with B. C. ratio of 2.15.

It is a high value crop and can fetch more prices if the produce is brought in cities. Further the cost of straw is not considered although it contains oil which has economical values. Only farmers' practices were taken for calculating the Cost of cultivation and net profit.

Analysis of input-Output Energy Use in Saffron Production system

Results revealed that the total energy used in various production processes for producing Kala zeera was 24, 739 MJ/ha. Among the production practices in kala zeera production, consumed tubers for cultivation (Seed) was the most energy consuming input(43.32 %). Safa *et al.* 2010 reported that total energy consumption for irrigated wheat, barley and maize were estimated at 51587, 53529 and 72743 MJ/ha, respectively. Therefore Kala zeera production in comparison to above crops is a low energy input production system. Kala zeera seeds are not used for cultivation; as it takes three years from seed to seed cycle. So vegetative propagules or root tubers are often used by farmers. Among the various forms of energy used as input during the production of Kala zeera. Manual power utilized for various operations was 108 man days which was equal to 756 hours amounting to energy of 1474.6 MJ. Mechanized power was when converted in terms of energy amounted to 1345. 3 MJ. Fossil fuel input to terms of energy was 5016.86 MJ. The fertilizer utilized when converted in terms of energy was found to be 5395.4 MJ which was 21.80% of the total energy input (Table 3). As far as the average yield of Kala zeera is concerned, approximately 150 kg/ha is obtained under field conditions as the per kg seed (dry mass) gives 21MJ, thus for 1 ha 21 x 150 = 3, 150 MJ which is almost double the energy utilized in producing the yield. Similar energy management has been worked out on cotton crop by Devasenapathy *et al.* (2009).

This indicates a high energy use efficiency which can even be increased by minimizing the energy utilized on different aspects especially labour and fertilizers. There are two ways for calculation of energy use efficiency in kala zeera, first based on total kala zeera output like seed and straw and second based on kala zeera seed only (Table 4). Tabar *et al.*, 2010 stated that with higher yields and improved agriculture practices in the wheat high input system, the unit of land used per unit of output reduced by 32 % in 2006 compared to 1990. It can be inferred that improvement in labour component and efficient usage of farm machinery will consequently lead to higher energy use efficiency.

Energy types of producing Kala Zeera

The total energy input consumed could be classified in kala zeera fields as direct (10.80%), indirect (25.60%), Renewable (43.33%) and non-renewable (20.27%) as illustrated in Table 2. The share of indirect energy input in kala zeera fields was 2.37times higher than direct energy input. The share of renewable energy input used in total energy input was around 2.14 times more than non-renewable energy in Kala Zeera fields. As a result production of Kala Zeera in view of relying to synthetic materials and energy conservation is an efficient system. The specific energy was 32.19 MJ/Kg (Based on seed and Straw). Canakci *et al.,* 2005 achieved specific energy for different field crops and vegetables in Turkey, such as 16.21 for Sesame, 11.24 for cotton, 5.24 for wheat, 3.88 for maize, 1.14 for tomato, 0.98 for melon and 0.97 for watermelon. Energy productivity was achieved 0.0311 Kg MJ^{-1} in Kala zeera production system. Net energy was -10, 181 MJ ha^{-1} in Kala zeera (Table 4). The application of renewable energy in Kala zeera production system was slight, indicating the fact that this system is relying extensively on renewable energies.

In other production systems, high consumption of fossil resources is considered to achieve higher yields. The utilization of fossil resources in agriculture threatens fertility of the soils and weakens economic independence of farmers.

Thus from the above finding it was concluded that diesel fuel is considered as the most energy consuming input was

Table 2: General cost of Cultivation of Kala Zeera

S.N.		Operations/Inputs	No./Qty	Rate (Rs).	Cost/ha with tractorization	Farmers way With bullocks
A		**Power cost**				
	1	Tractorization	3 tillings	200/Kanal	4000/=	
`	2	Tillage with bullocks	20 pairs			4000/=
		Total			**4000/=**	**4000/=**
B		**Material cost**				
	1	Cost of seed	1, 60,000 tubers	3/ tuber	**4, 80, 000/6year 80, 000/ year**	**4, 80, 000/6year 80, 000/ year**
	2	Cost of fertilizer				
	a	N= 80Kg/ha	Urea =141 Kg/ha	15/Kg	2115/=	2115/=
	b	P_2O_5 = 40 Kg/ha	DAP=83.33 Kg/ha	25/kg	2083/=	2083/=
	c	K_2O = 30 kg/ha	MOP= 50kg/ha	25/kg	1250/	1250
	3	Cost of plant protection			800/=	800/=
		Total			**85448/=**	**85448/=**
C		**Labour cost**				
	1	Fertilizer application	2 labours	500/=	1000/=	1000/=
	2	Sowing of seeds by line method				
	a	Opening of furrows	30 labours	500/=	15000/=	15000/=
	b	Placing of propagules & covering of furrows	14 labours	500/=	7000/=	7000/=
	4	Weeding , hoeing and thinning	20 labours	500/=	10000/=	10000/=
	5	Harvesting &tieing	12 labours	500/=	6000/=	6000/=
	6	Threshing, cleaning etc.	10 labours	500/=	5000/=	5000/=
		Total			**53,000/=**	**53, 000=**
		Grand Total			**1,42,448/=**	**1,42,448/=**
		Returns				
		Seed yield	150 Kg/ha			
		Straw	620			
		Cost of one Kg Seed	Rs. 3000/=			
		Cross returns	Rs. 4,50,000/=			
		Net returns				

Table 3: Energy consumption and energy input-output relationship in Kala Zeera Production.

Items	Quantity per unit area (ha)	Energy equivalent (MJ/ Unit)	Total energy equivalent (MJ)	Percentage of total energy input
INPUT Energy				
Field Preparation (30 Labour)	180 hr	1.95	351	1.42
Formation of beds, Furrows and Sowing (44 Labours)	264 hr	1.95	514.8	2.08
Fertilizer application (2 labour)	12 hr	1.95	23.4	0.09
Weeding/Hoeing/Thinning (20 Labour)	120 hr	1.95	234	0.95
Harvesting and Tieing (12 Labour)	72 hr	1.95	140.4	0.57
Threshing and Cleaning (10 Labour)	60 hr	1.95	117.0	0.47
Machinery	21.46	62.70	1345.36	5.44
Diesel Fuel (L)	99.88	50.23	5016.86	20.28
Nitrogen (kg)	60	75.46	4527.6	18.30
Phosphate; P2O5 (kg)	40	13.07	522.8	2.11
Potash ; K2O (kg)	30	11.15	345	1.39
Herbicide (kg or L)	2	238.32	476.6	1.93
Fungicide (kg or L)	5	92.01	460.05	1.86
Propagules/ Seed (kg)	4300/6years or 716/Year	14.97	10718	43.32
Total Input **24739**				
OUTPUT				
Kala zeera Seed Yield	150 kg	21.0	3150	
Kala zeera straw Yield	620 kg	18.4	11408	
Total Output energy			**14,558**	
Energy Use Efficiency			0.58	

followed by nitrogen in rainfed Kala zeera production system. Overall in view of sustainability kalazeera was an efficient production system. However in terms of energy efficiency it is important to reduce the input energy consumption especially in terms of labours, diesel and fertilizers. In this condition improving timing, quantity and appropriate method and finding substitute sources of energy will increase energy use efficiency which in turn reduces the environmental contamination

Table 4 : Total Energy Input in the form for Direct. Indirect, Renewable and non Renewable Energies for Kala Zeera

Type of energy	Kala zeera	
	(MJ ha $^{-1}$)	%age of Total
Direct Energy	2672.0	10.80
Indirect Energy	6332.05	25.60
Renewable Energy	10718	43.33
Non - Renewable Energy	5016.86	20.27
Total Energy input	24739	

Direct energy : Human Labour and Machinery
Indirect Energy: Fertilizers, weedicides, Fungicides
Non Renewable Energy: Deisel Fuel
Renewable Energy: Propagating material or tubers

Table 5 : Energy Input-Output Ratio in Kala Zeera Production system

Items	Unit	Kala Zeera
Energy input	MJ ha $^{-1}$	**24739**
Energy Output	MJ ha $^{-1}$	**14,558**
Energy use efficiency (Based on Seed and Straw)	MJ ha $^{-1}$	0.58
Energy Use efficiency (Based on Seed)	MJ ha $^{-1}$	0.127
Energy intensiveness	MJ Rs $^{-1}$	0.174
Specific Energy	MJ Kg $^{-1}$	32.19
Energy Productivity	Kg MJ $^{-1}$	0.0311
Net Energy	MJ ha $^{-1}$	10,-181

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