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Energy Input-Output Analysis of Aggregatum Type Onion Cultivation in Karnataka State

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ABSTRACT: Energy input–output analysis in production and post–production agriculture is very important for developing efficient and sustainable crop production systems. Crop production is highly dependent on yielding varieties, chemicals, fertilizers, mechanization and other energy inputs. Onion (*Allium cepa* L.) is one of the most important commercial vegetable crop widely cultivated in India. Indian onions are broadly classified into three types *viz*., common onion, small common onion and aggregatum onion. Aggregatum type onion is widely used in Tamil Nadu and Kerala cuisine owing to its special flavour and pungency traits as well contributed significant nutritional value to the human diet as well medicinal value. This is widely grown in Southern states of India *viz*., Tamil Nadu, Karnataka and Andhra Pradesh, mainly by small and marginal farmers. A study was carried out to estimate and analyse the energy input-output of aggregatum type onion cultivation in Karnataka State. The farm operations for aggregatum onion cultivation are land preparation, planting, manure and fertilizer application, plant protection, irrigation, harvesting and detopping. The data was collected by survey through structured schedule and data was converted into respective energy equivalents. The energy parameters in terms of direct energy (included men, women, tractor, diesel and electricity), indirect energy (included seed, fertilizer, pesticide and machinery) and output energy were calculated. Fertilizer energy (11,911.49 MJ/ha) was the maximum utilized energy source followed by diesel (6,228.98 MJ/ha) and electricity (5,677.27 MJ/ha) contributing about 40%, 21% and 19% of input energy. Fertilizer application (12,051.07 MJ/ha) had the highest share of energy consuming farm operation followed by irrigation (5,901.53 MJ/ha) and land preparation (5,664,71 MJ/ha). Aggregatum type onion cultivation consumed 29,378.44 MJ/ha total input energy (out of which 53.22 % direct energy and 46.78 % indirect energy). The output energy was calculated as 25,095.20 MJ/ha with energy productivity of 0.54 kg/MJ., it was concluded that fertilizer was the highest utilized energy sources (40.54%) followed by diesel (21.20%) and electricity (19.32%). From the above study it was concluded that consumption of fertilizer, diesel and electricity should be optimizied. In case of fertilizer, use of liquid fertilizes, nano fertilizer and adoption of natural farming may be validated through research and then many be recommended to the onion growing farmers. By adopting E-tractor or E-prime movers for farm operations will lead to reduction in use of diesel consumption. Farmers should be encouraged to use solar powered water pumps in place of electrical pumps to reduce the electrical energy. Energy from farm women also contributes significantly as input energy source. Farm women are engaged in planting of onion bulbs, weeding, harvesting and detopping operations of onion cultivation operations. Machineries are available for onion bulb planting, harvesting and detopping need to be widely demonstrated to the onion growing farmers for adoption thus leading to reduction the input energy in onion cultivation.

Keywords: Aggregatum type onion, direct energy, indirect energy, energy input-output, energy productivity.

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important commercial vegetable crop widely cultivated in India. Indian onions are broadly classified into three types *viz*., common onion, small common onion and aggregatum onion. Primarily common and small common onions are single bulbs but vary largely in size. Whereas aggregatum onion also called as multiplier onion (*Allium cepa* L. var. *aggregatum* Don) is small-sized bulbs, many to form an aggregated cluster (Hanlet, 1990). This is widely grown in Southern states of India *viz*., Tamil Nadu, Karnataka and Andhra Pradesh, mainly by small and marginal farmers. Unlike common onion, aggregatum type onion is propagated through vegetative means (bulblets also called assets (Sumanaratne *et al.*, 2002).

Aggregatum type onion is widely used in Tamil Nadu and Kerala cuisine owing to its special flavour and pungency traits as well contributes significant nutritional value to the human diet. Apart from food value, it also has medicinal properties, reported to cure, reduce, or prevent some of the health problems, such as asthma, cancer, cardiovascular diseases, and possess anti-diabetic, antibiosis, and prebiotic effects (Desjardins 2008).

Kerala's cuisine widely prefers aggregatum type onion and this type of onion does not grow in Kerala Agroclimatic conditions. Kerala produces only 30 MT under 310 ha area (NHB, 2018) and state's requirement is met by procuring from the neighbouring state Karnataka. Aggregatum type onions are cultivated in Chamarajanagara, Mandya and Mysuru Districts of Karnataka covering an area of 6,129 ha with a production of 1,22,972 MT(www.horticulture.kar.nic) though this type of onions are not used in Karnataka State cuisine. The farmers of these three districts cultivate aggregatum type onions only to supply to Kerala State as these three districts are situated in the borders of Kerala and Karnataka (Fig. 1) and the agroclimatic conditions of this area is suitable for cultivation of aggregatum type onion.

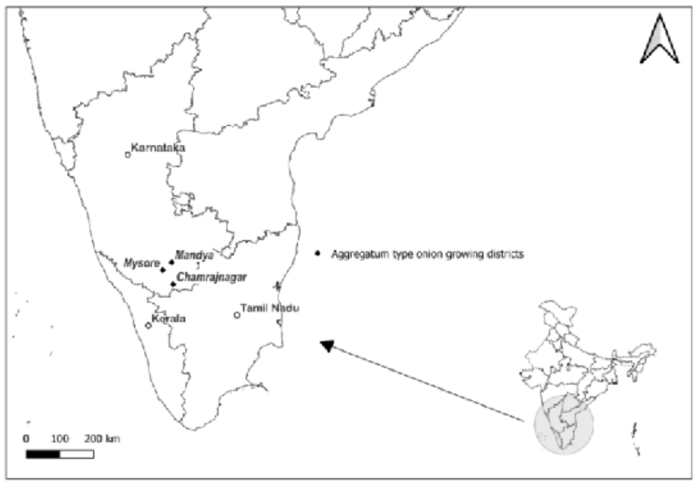

Fig. 1. Aggregatum type onion growing areas in Karnataka State.

Energy is a critical issue in food security, but one which is often overlooked. Energy efficiency is defined as "the ability of producing the same level of output with minimum used resources (Allali *et al.*, 2017). Energy use in agriculture has developed in response to increasing populations, limited supply of arable land and desire for an increasing standard of living. In all societies, these factors have encouraged an increase in energy inputs to maximize the yields and to minimize labour-intensive practices, or both (Esengun *et al.*, 2007a&b).

Efficient use of energy contributes to the economy improving profitability, productivity and competitiveness of agricultural sustainability in rural areas (Ozkan *et al.*, 2007). Energy use efficiency can be increased by improving outputs such as crop yield and by reducing inputs such as tillage operations and consumption of pesticides and fertilizers (Bailey *et al.*, 2003). Energy use in agriculture has been developed as a response to increasing populations, limited supply of arable land and desire for an increasing standard of living (Mohammadi *et al.*, 2008; Unakıtan & Aydın 2018).

Energy input–output analysis in production and post–production agriculture is very important for developing efficient and sustainable crop production systems. Crop production is highly dependent on yielding varieties, chemicals, fertilizers, mechanization and other energy inputs, which would be further affected by level of technology and agro-climatic zone. Energy input and crop yield vary with farming systems and will ultimately influence on the energy output–input ratio. The increase in energy inputs obviously, increases crop production and productivity. But, increase in fertilizers or other similar inputs per ha may not result in raising yields indefinitely due to biological principle of diminishing returns (Tripathi *et al.*, 2015).

Energy input–output analysis have been widely studied and reported for many field crops and cropping patterns. Energy use in vegetable production systems have been studied and reported (Bockari-Gevao *et al.*, 2004; Demircan *et al.*, 2006; Canakci *et al.*, 2005; Ozkan *et al.*, 2004; Hatirli and Ozkan 2006; tomato Esengun *et al.*, 2007), garlic (Samavatean 2010), tomatoes (Jadida *et al.*, 2012; Taki *et al.*, 2013) and cucumber (Mohammadi and Omid 2010). Energy use efficiency and economic analysis of pulses production in Iran was done by (Koocheki *et al.*, 2011). (Chaudhary *et al.*, 2009) reported that in maize–pea–wheat and rice–pea–wheat–green gram cropping systems.However, study on energy analysis especially for onion production is very limited. Therefore, present study was undertaken to estimate and compare the energy requirements for production of aggregatum type onion cultivated in Karnataka State.

MATERIALS AND METHODS

Study Area. Aggregatum type onion is cultivated in an area of 3000 ha in the Gundlupet (Tk.) of Chamarajanagar (Dt.) of Karnataka state contributing the highest aggregatum type onion production (60,000 MT) from Karnataka State (www.horticulture.kar.nic). A onion growing village, Baragi belongs to Gundlupet (Tk.) was selected for collecting data on energy input and output analysis of aggregatum type onion cultivation. Baragi village is located at a Latitude of 11° 48' 29.52" Nand longitude 76° 41' 27.74" E. The soil type of Baragi Village is Black Cotton Soil. This village constitutes Southern Dry Zone of Karnataka Agro climatic Zones.

Farm operationsin aggregatum type onion cultivation. The various farm operations involved in cultivation of aggregatum onion are field preparation, bulb planting, irrigation, weeding, chemical spraying, fertilizer application, harvesting and top clipping (detopping). Interactive survey was carried out in the Baragi village of Chamarajanagar (Tk.) and the data was collected (N=20) as per the survey schedule (Chandra *et al.*, 2021). Energy equivalents were used to calculate the energy required in each farm operation of onion cultivation (Anon, 1999).

Energy calculation. The various implements used for field preparation were disc plough, 5-tyne cultivator and rotovator using tractor followed by bed preparation by bund former. Electric pump was used for irrigation and sprayer was used for plant protection operation. The machine energy required for the above operations were calculated using the following relationship.

$$\text{Machine energy (MJ/ha)} = \frac{\text{Weight of machine (kg)}}{\text{Life span of machine}} \times \text{Energy equivalent (MJ)} \times \text{Operational hours (h)}$$

The energy input from human, animal, diesel, seed, electricity, weedicides, pesticides, farm yard manure and fertilizer were calculated by multiplying the physical unit with the respective energy equivalents as presented below.

Diesel energy (MJ/ha) = Diesel consumption (L) × Energy equivalent (MJ) × Operational hours (h)

Men (Driver) energy (MJ/ha) = Energy equivalent (MJ) × Operational hours × No of men labours

Onion bulb energy (MJ/ha) = Quantity of onion bulbs × Energy equivalent (MJ)

Women energy (MJ/ha) = No of women labourers × Operational hours (h) × Energy equivalent (MJ)

Weedicide energy (MJ/ha) = Quantity of weedicide (kg) × Energy equivalent (MJ)

Fertilizer energy = Weight of the fertilizer (kg) × Energy equivalent (MJ)

Total Output energy. The total output energy is computed from the yield of the aggregatum onion per unit area. The total output energy was calculated using the following equation.

Total output energy (MJ/ha) = Weight of the yield/ha × Energy equivalent (MJ)

Every operation consists of two types of energies *i.e*., direct and indirect energy. The energy contributing from men, women, tractor, diesel and electricity sources are categorized as direct sources and energy contributing from seed, fertilizer, pesticide and machinery are categorized as indirect sources. Accordingly, calculations were carried out and tabulated.

RESULTS AND DISCUSSION

The survey was carried at Baragi Village, Gundlupet (Tk.) of Chamarajangar (Dt.) of Karnataka (Dt.). Data was collected through stratified random sampling method, the operation wise and source wise energy values were computed and tabulated (Table 1).

From Table 1, it was observed that in case of operation-wise input energy sources, the highest energy consumption was observed with fertilizer application (12,051.07 MJ/ha) followed by irrigation (5,901.53 MJ/ha), land preparation (5,664.71 MJ/ha), planting (2,831.83 MJ/ha), plant protection (1,634.89 MJ/ha), detopping (667.76 MJ/ha) and harvesting (626.67 MJ/ha). The operation fertilizer application comprises of two major source wise components *viz*., direct and indirect sources. Direct energy sources include men and women. Indirect energy sources include fertilizer. It was observed that fertilizer (11911.49 MJ/ha) was the highest input energy cosuming input source. The similar results of highest energy consumption of fertilizer energies for onion production was reported by (Allali, *et al.*, 2017; Ibrahim 2011). Similar results have been reported by (Tripathi *et al.*, 2015) for pea production.

Percentage of input energy for different unit operations namely, land preparation, planting, manure and fertilizer, plant protection, irrigation, harvesting and detopping for onion cultivation were 19.28%, 9.63%, 41.02%, 5.56%, 20.08%, 2.13% and 2.27%, respectively (Fig. 2). It was observed that in case of fertilizer application (41.02%), energy from fertilizer (40.54%) was the major source whereas energy from men and women were 0.31%, 0.16%, respectively.

Similarly, in case of irrigation (20.09%), energy from electricity (19.32%) was the major source whereas energy from men, machinery and others were 0.58%, 0.18%, 0%, respectively. In case of land preparation (19.28%), energy from diesel (18.67%) was the major source whereas energy from men, tractor, machinery and others were 0.08%, 0.51%, 0.01%, 0%, respectively. Sepat *et al*. (2013) reported similar findings stating that diesel energy consumption was high agricultural inputs as it is being used in field preparation and transportation.

Further, it was also observed that, utilization of women energy was significantly higher (10.53%) whereas, men energy was very less (1.59%). About 4.63% of women energy was utilized for plant protection operation. Further, it was observed that energy utilised from tractor and machinery energy were found to be nascent 0.57% and 0.20%. The results obtained were in accordance with the results reported by Patel *et al*. (2014); Yadav *et al*. (2017); Osbek *et al*. (2021).

Table 1: Source-wise and operation-wise energy input for aggregatum type onion production.

Unit Operation	Direct (MJ/ha)					Indirect(MJ/ha)				Grand Total (MJ/ha)
	Men (MJ/ha)	Women (MJ/ha)	Tractor (MJ/ha)	Diesel (MJ/ha)	Electricity (MJ/ha)	Seed (MJ/ha)	Fertilizer (MJ/ha)	Pesticide (MJ/ha)	Machinery (MJ/ha)	
Land Preparation	24.81	0.00	150.04	5485.53	0.00	0.00	0.00	0.00	4.32	**5664.71**
Sowing	7.75	482.80	17.033	743.45	0.00	1580.80	0.00	0.00	0.00	**2831.83**
Manure & Fertilizer	91.50	48.09	0.00	0.00	0.00	0.00	11911.49	0.00	0.00	**12051.07**
Plant Protection	81.33	1361.14	0.00	0.00	0.00	0.00	0.00	191.18	1.24	**1634.89**
Irrigation	170.65	0.00	0.00	0.00	5677.27	0.00	0.00	0.00	53.61	**5901.53**
Harvesting	0.00	626.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**626.67**
Detopping	91.50	576.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**667.76**
Total	**467.54**	**3094.95**	**167.07**	**6228.98**	**5677.27**	**1580.81**	**11911.49**	**191.18**	**59.17**	**29378.44**

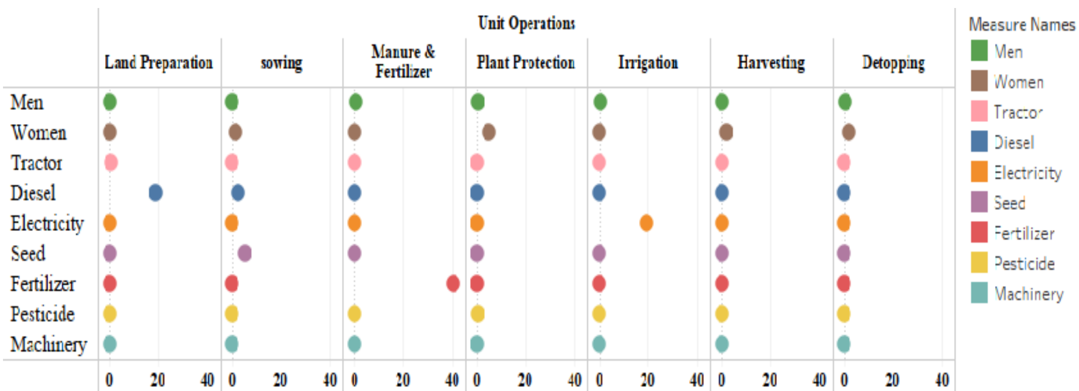

Fig. 2. Input Energy use pattern for aggregatum type onion cultivation.

Energy parameters. From Table 2, the different energy parameters *viz*., direct, indirect, total input, output energy, energy ratio, specific energy and energy productivity in aggregatum type onion cultivation were observed to be 15,635.81±648.78 MJ/ha, 13,742.63±1674.04 MJ/ha, 29,378.44 ±1904.05 MJ/ha, 25,095.20±2651.08MJ/ha, 0.86±0.12, 1.89±0.23 MJ/ha and 0.54±0.07 kg/MJ, respectively. The utilization of total direct energy source (15,635.81 MJ/ha= 53.20%) was found to be highest as compared to the total indirect energy sources (13,742.63 MJ/ha= 46.80%). It was also observed that total input energy was highest (29,378.44 MJ/ha) as compared to total output energy (25,095.20 MJ/ha) (Fig. 3).

Table 2: Energy parameters for aggregatum type onion cultivation.

	Direct Energy (MJ/ha)	Indirect Energy (MJ/ha)	Total Input Energy (MJ/ha)	Yield, (kg/ha)	Total Output energy (MJ/ha)	Output/Input Ratio	Specific Energy (MJ/Kg)	Energy Productivity (kg/MJ)
Mean	15635.81	13742.63	29378.44	15684.50	25095.20	0.86	1.89	0.54
Standard Deviation	648.79	1674.05	1904.06	1656.93	2651.08	0.12	0.23	0.07
Minimum	14342.85	10507.75	25709.90	12350.00	19760.00	0.67	1.33	0.42
Maximum	16730.30	15699.37	32429.67	19760.00	31616.00	1.21	2.40	0.75
Confidence Level(95.0%)	303.64	783.48	891.1262	775.46	1240.75	0.05	0.11	0.03

CONCLUSIONS

A study was conducted at Gundlupet (Tk.) of Chamarajanagar (Dt.) of Karnataka to assess the energy utilization for aggregatum type onion cultivation. From the above study, the following conclusions were drawn: The total input energy utilised for cultivation of aggregatum type onion was 29,378.44± 1904.05 MJ/ha and output energy was 25,095.20 ± 2651.08 MJ/ha with the energy ratio of 0.86±0.12. Energy utilized for fertilizer application was observed to be the highest as 40.54 per cent followed by irrigation (19.32%) and land preparation (18.67%). Further, when all the nine associated energy sources (direct sources: men, women, tractor, diesel and electricity, indirect sources: seed, fertilizer, pesticide and machinery) were considered which contributes for the above three farm operation in onion cultivation, it was concluded that fertilizer was the highest utilized energy sources (40.54%) followed by diesel (21.20%) and electricity (19.32%). By utilizing the fertilizer, diesel and electricity optimally, the energy ratio can further be increased as well reduction in inputs coupled with soil health. It was also clear that energy from farm women contributing significantly as input energy source. Farm women are engaged in planting of onion bulbs, weeding, harvesting and detopping operations of onion cultivation operations. Machineries are available for onion bulb planting, harvesting and detopping. These machinery need to be widely demonstrated to the onion growing farmers for adoption thus leading to reduction in input energy in onion cultivation.

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Conflict of Interest. None.

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