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Analysis of energy used on shallot farming in Food Estate, Hutajulu, North Sumatra

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Abstract. *Food Estates* is a government program proposed to meet the growing population's food needs. Data from the field show the use of diesel fuel, electricity and chemicals in applying pesticides, fertilizers and fungicides that negatively impact the environment and require strategies to improve energy efficiency. This study analyzed the energy used for shallot farming of 0.2 ha. Shallot cultivation involves the following stages: 1) ploughing with a tractor along with a trailer. 2) planting and maintenance, 3) harvesting, and 4) transportation. Each stage of shallot cultivation uses input from natural resources or energy. The result shows that the highest energy was for manure application (23,116.41 MJ/ha), while the lowest was electricity energy.

1. Introduction

The increase in population in Indonesia makes a surge in demand for food that is proportional to the increase. In order to achieve the expected food security, one of the ways to be taken is the existence of a food estate program designed by the government as a food shed.

Food estate is applied with the concept of industrial agriculture based on knowledge and technology (digitalization farming) in areas that have the potential to be used as food reserves with extensive enough land and land conditions that meet standards. One food estate location is Hutajulu Village, Pollung District, Humbang Hasundutan Regency, North Sumatra Province.

The horticulture-based food estate program aims to develop horticultural areas by considering environmental friendliness and a more modern, competitive system and is expected to be a solution to solving food problems. The commodities grown at the Food estate location are potatoes, shallots, corn, stevia plants, and chillies.

Shallot (*Allium ascalonicum* L.) is one of the horticultural commodities in Indonesia. In recent years, shallots have received incentive attention, especially from agricultural actors and the government, making shallots one of the top six vegetable commodities. Shallots have the same popularity as other commodities, namely cabbage, blunkol (cabbage flowers), chillies, tomatoes, and potatoes. In the world of exports and imports, shallot commodities are not only exported in the form of fresh bulbs but also processed products such as fried onion products.

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Each year, the annual productivity of shallots in Indonesia increases by 5% for domestic consumption and seed production. West Java, Central Java, East Java, South Sulawesi, West Nusa Tenggara, and West Sumatra are provinces that produced shallots as the primary commodity in 2017. In 2021, shallot production in North Sumatra Province achieved annual productivity of shallots of 53,775.4 tons/ha [1].

Energy is a source of energy (power source) that exists in various activities. Energy demand in agriculture is a source of energy used in the agricultural sector, including fuel, electricity, fertilizers and other chemicals used during agricultural cultivation. The energy input or demand significantly influences the energy output or energy released, such as gas emissions, in modern agricultural systems and conventional agriculture [2].

The mechanized energy during cultivation consists of the use of gasoline, which is then switched more fuel-efficiently to a diesel-powered engine that is more fuel-efficient. This is for energy-efficient tillage conservation practices, more appropriate machine sizes for cultivation with energy-efficient methods and crop drying and irrigation [3]. The use of mechanized energy using new machines and applied in cultivation systems and land management can reduce energy requirements by around 18-83% for each different cultivation system. Using chemical fertilizers and pesticides is also known to increase energy demand in agriculture and yields simultaneously in conventional farming systems [4].

Energy demand is the energy consumption used during cultivation, from land preparation to post-harvest. In agriculture, the energy requirements are usually analyzed from the use of fuel from agricultural tools and machines, the energy produced by fertilizers, pesticides and electricity during the cultivation process to achieve optimum yields.

2. Materials and Methods

The materials used in this study were data and information obtained from the Hutajulu *Food Estate* for four months (February-June, 2022), from seeding to harvesting, on aspects of the volume of water use, electrical energy, chemical fertilizer energy, transportation energy, and fuel energy. The energy use was determined by using the energy coefficient as input energy and output energy. The energy coefficient of input energy, for instance, mechanization tractor is 9-10 MJ/kg per year, 78.1 MJ/kg for Nitrogen (N) fertilizer, 17.4 MJ/kg for Phosphate (P_2O_5) fertilizer, 13.7 MJ/kg for Potassium (K_2O) fertilizer [5], while the energy coefficient for pesticides, electricity, manure, transport and irrigation are 120 MJ/kg [6], 12 MJ/kWh [5], 0.3 MJ/kg [7], 1.6-4.6 MJ/km [8], 0.63 MJ/m^3 [9], respectively. The output energy is shallot (1.85 MJ/kg)[5].

Fuel consumption was obtained using the Full to Full method to determine how many litres are spent cultivating the land or carrying out other processes with agricultural machines. The Full to Full method was applied before the engine runs, the engine oil tank was filled in full, and then the engine was run until the processing or process observed to run entirely. When the operation was finished, the tank was again filled in full with fuel while measuring how many litres were used up. As long as the agricultural machinery is operating in the field, the operating time was calculated, and the data was used the operator's calorie calculation.

Some supporting data are needed to find out the calorie consumption used at work, such as age, weight, height, duration of activity and level of activity performed. The basal metabolism was determined by Equation 1 [10].

$$\text{Basal metabolism} = [66.5+(13.7\times\text{weight})+(5\times\text{height})-(6.8\times\text{age})]\ (\text{kkal}) \quad (1)$$

3. Results and Discussions

Food Estate's shallot products were cultivated by seeding three species: Maserati, Locananta, and Sanren. The available land area for the food plantation was 0.04 ha, of which 0.20 ha was used for transplanting. This nursery requires many steps before the plants may be transplanted. Figure 1 depicts the energy needed for nursery and maintenance growth.

Create beds for sowing three types of shallots on the arable ground, including Maserati, Locananta, and Sanren. Before planting, organic fertilizer and shell charcoal are added to these bed after their preparation. This step was manually executed. The dimensions of a planting bed with an area of 0.2 hectares are 60.64 meters in length and 1 meter in width. Shallots were sown by laying seedbeds with a row spacing of 15 centimetres and a spreading density of 40 grams per square meter on the bed and covered with coconut shell charcoal.

The seedbed was treated with a fungicide later the same day to keep it mould-free and sealed to stimulate seed germination and preserve humidity. The purpose of the cowl was to shield the sowed seeds from rain and intense sunshine. A bamboo frame and a plastic hood constitute the hood. Maintenance was performed manually by watering in the morning or evening; the total water used in irrigation was 81.56736 m^3. The plants are then safeguarded from pests and diseases by regularly applying fungicides, insecticides, and fertilizers.

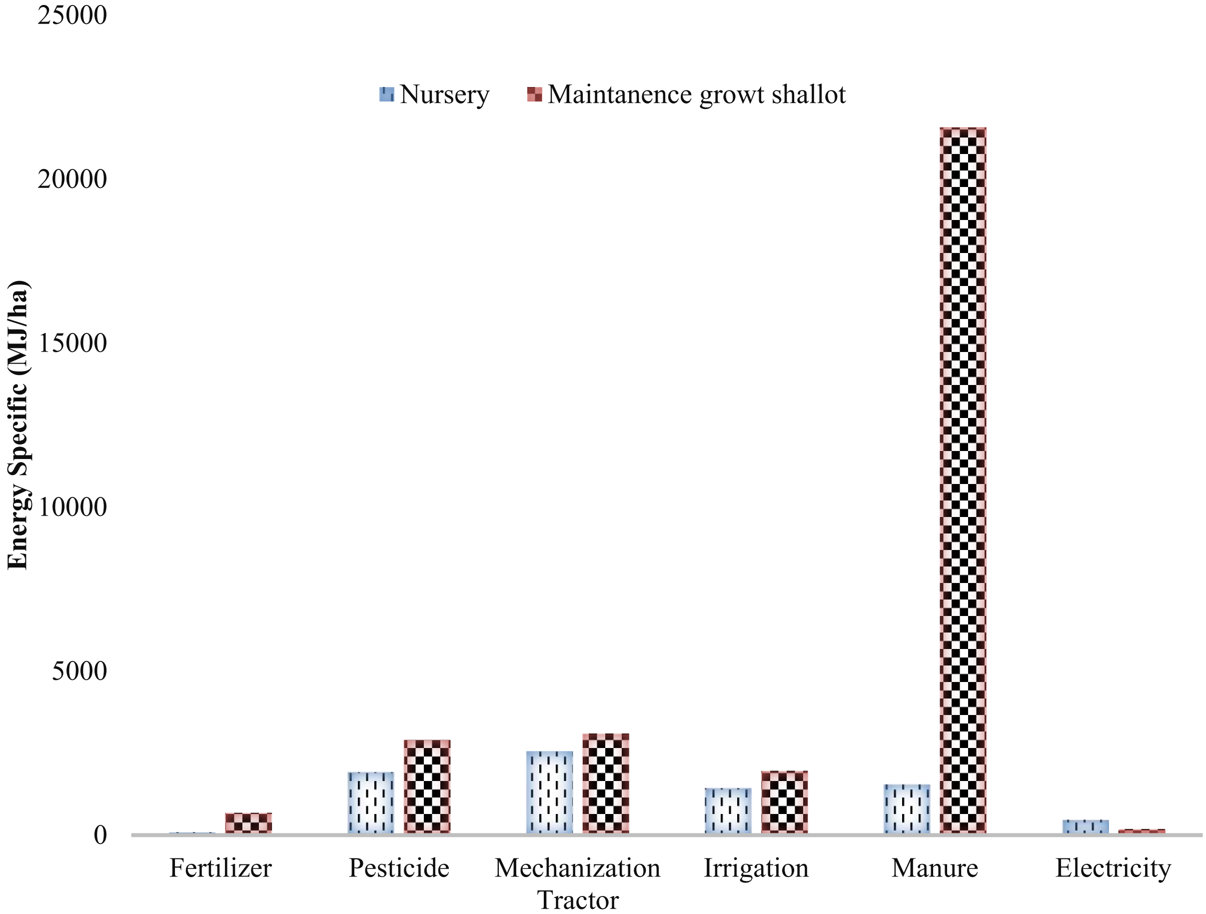

Figure 1. Energy specific of shallot farming in nursery and maintanence growth.

Tillage was done in several stages by agricultural mechanization. It started with making rotary platforms, leveling, manure spreading, rotary harrows, and beds.

Subsequent ploughing was done circumferentially. Rotary on Food Estate used his 45-hp KIOTI DK4510 tractor, intended to plough the soil with a working system that has been set. The rotating implement has a blade that moves on an axis driven by a motor, which chops up the soil.

Terrain leveling was performed by measuring the slope of the terrain using a Mileseey PF210 600m golf rangefinder. Land with a slope greater than 5 degrees is leveled or graded with a Kamol tractor or D31P bulldozer. Bulb 6 land, which is the habitat of the shallot, does not require land clearing as the land slope is 3°.

The shallot growing area of the food estate was covered with manure in the form of cow dung for a total of 7.99 m^3. Fertilization by mechanization, i.e. a 120 hp agricultural tractor with a manure spreader with a capacity of 5.92 m^3.

The next stage after liquid fertilizer application is the rotary harrow. The rotary harrow is one of the devices that has function of loosening soil to a depth of 35 cm, crushing the soil into smaller sizes and mixing soil with the fertilizer that was spread on the soil surface. The power harrow used rotating blades driven by a rotor with nine pairs of blades. The rotary harrow version was coupled to a 120 hp agricultural tractor.

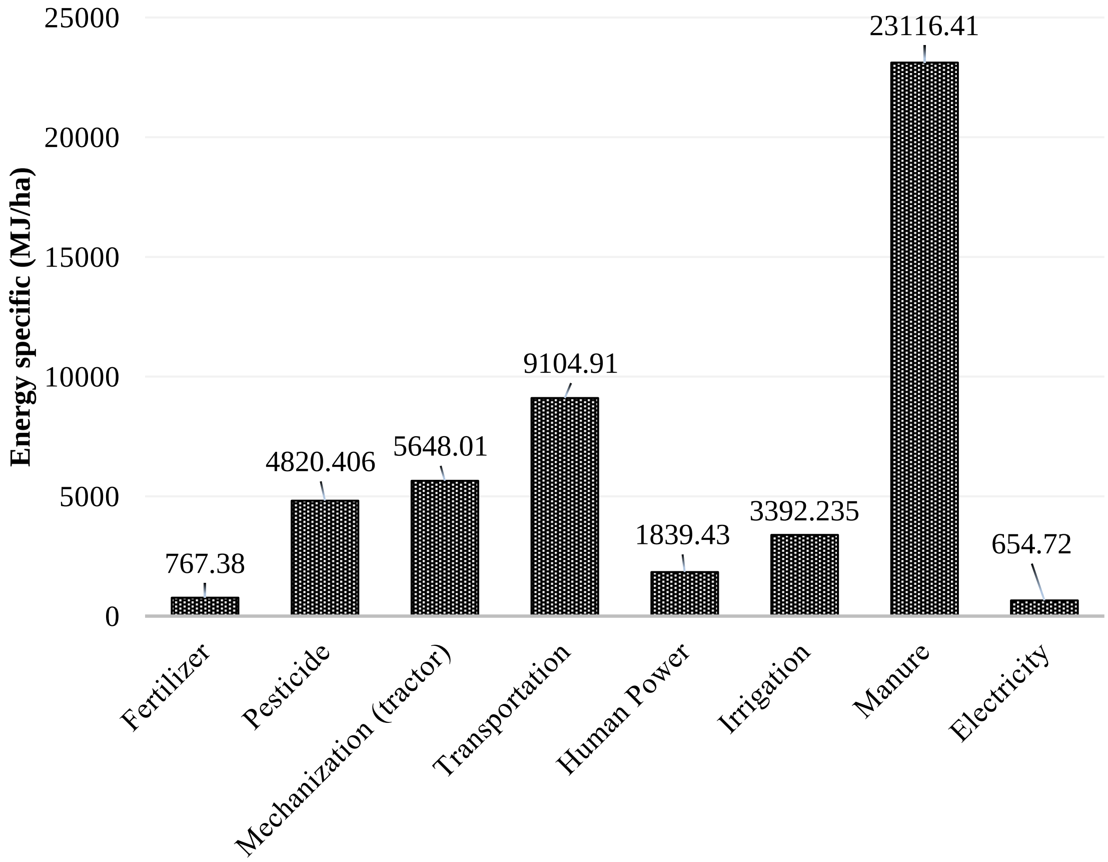

Figure 2. Energy specific of shallot farming.

Land beds for food crops, including shallot products, are performed using a 77 HP Camor tractor in conjunction with a disc bed tool. The bed width was adjusted to 90 cm with a disc spreader and the distance between beds was 60 cm.

Fertilizers, fungicides and insecticides were applied during the maintenance stage of shallot cultivation, each of which has respective function and role in the plant, a fertilizer formulation containing Zn in the form of white crystals which are 100% soluble in air and free of sediment. The function of this fertilizer is to promote plant growth, induce the growth of new shoots and increase the yield by increasing fruit or tuber size.

Harvesting was done manually by human power. Analysis of energy expenditure from sowing to harvest was calculated according to Hutabarat [10] using age, height, weight, working hours and high or moderate activity level. The total manpower for this food estate program was 88,011.1 kcal. The transportation used to transport manure or compost process by Colt diesel trucks with a distance of 207 kilometres and a consumption of 25.875 litres of diesel fuel. Transporting shallots using refrigerated diesel trucks to towns within a 198 km radius of Hutajulu in Humbang Hasundutan consumed 24.75 litres. Based on Figure 2, the highest energy used was in the manure application.

4. Conclusions

Food Estate's shallot products are grown by sowing shallots from three species of shallot: Maserati, Locananta and Sanren. The higest energy used was for manure application (23,116.41 MJ/ha), while the lowest energy used was for electricity.

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