International Journal of Multidisciplinary Research and Publications
ISSN (Online): 2581-6187

Environmental Performance of PHilMech Multi-Row Onion Seeder in Iloilo, Philippines

Edgar D. Flores[1], Rodelio G. Idago[2]
[1,2]Philippine Center for Postharvest Development and Mechanization (PHilMech)
CLSU Compound, Science City of Muñoz, Nueva Ecija, Philippines, 3120
Email address: edulayflores@gmail.com

Abstract— *The environmental performance of planting bulb onion using the PHilMech multi-row onion seeder (MROS) was evaluated and compared with the traditional transplanting method in Iloilo Province, Philippines. Correspondingly, lower input energy was obtained when MROS was used as planting method at 27,168.06 MJ/ha compared to transplanting method at 30,678.46 MJ/ha due to the reduction of labor and diesel fuel during seedling production, pulling-up, and transplanting of seedlings. Non-renewable and indirect forms of energy had contributed most to the total input energy in both production systems where chemical fertilizer had the highest share followed by diesel fuel. A kilogram of onion produced had emitted 0.184 kgCO_2eq for the system using MROS lower than 0.208 kg CO_2eq accounted for the system using the transplanting method. The MROS can be an alternative planting technology that could ease the need for a large quantity of labor during onion planting. The MROS can provide the farmers with relatively bigger farm areas to schedule planting without worrying about the availability of labor and at the same time reduces environmental burdens by having lower input energy and CO_2 emissions.*

Keywords— *Bulb onion, seeder, carbon dioxide, energy, emission.*

I. INTRODUCTION

Onion (*Allium cepa L.)* is considered one of the major economic crops grown in the Philippines with an average annual production of 175, 594.41 MT, valued at PhP 6.80 billion (PSA, 2019). It plays an important role in the livelihood of Filipino farmers, serving as a major source of employment in rural areas, especially in regions where the crop is commonly cultivated. Recently, the Department of Agriculture (DA) has declared Iloilo as the new hub for onion production in the country. The province has devoted 210 hectares to onion and has been targeted to expand to 2000 hectares in the succeeding years. Along with the other crops, onion production faces various challenges, including an insufficient number of laborers during planting; high cost of labor; insufficient storage facilities; and fluctuating market prices. Thus, the DA through the Philippine Center for Postharvest Development and Mechanization (PHilMech) strives to mechanize the agricultural production and handling system of onion to enhance the overall productivity of onion farms.

Due to the aggressive move towards the mechanization of agricultural production systems, the use of energy resources is expected to increase. However, the use of excess energy leads to several human health risks and environmental problems. Therefore, reducing fossil energy inputs in the agricultural system is necessary to reduce carbon dioxide emissions (Ghorbani et al., 2011). The energy input required in mechanized farming can be greater than the traditional farming systems. With this, energy must be used efficiently because there is no guarantee that an increase in energy input in crop production can increase yield and income due to an increase in the cost of production as well (Erdal et al., 2007). The efficient use of energy is one of the requirements to achieve sustainable agricultural production, as it leads to financial savings by lowering production costs, conserving fossil resources, and reducing air pollution (Uhlin, 1998). Besides energy, emissions of greenhouse gases are also important in agricultural production (Khoshnevisan et al., 2013). Due to agricultural activities, gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are usually emitted and enhance the natural greenhouse effect.

Because of the continued aging of farmers and the increasing migration of many young people from the countryside to the cities, most farmers have problems finding enough labor due to the simultaneous farming activities of each farmer which may cause a delay in the schedule of farm operations (Gavino et al, 2020). Correspondingly, the planting season of onion coincides with the harvest season of palay. Most often, laborers prefer to harvest palay than to plant onion because the wage rate for harvesting palay is higher than planting onion. Although the mechanical seeder has been tested in other areas in Luzon (Antolin et al., 2018; Flores et al., 2018), the practices and conditions in Visayas like Iloilo are different which need further study to adopt the seeding technology. Thus, intending to address the problem of insufficient labor during the planting of onions and to reduce the cost of production, this study evaluated the applicability of the multi-row onion mechanical seeder in the province of Iloilo. The energy use and greenhouse gas emissions following the integration of PHilMech MROS in the whole onion production system were estimated and compared with the traditional production system.

II. METHODOLOGY

A. Environmental performance system boundary

The PHilMech multi-row onion seeder (MROS) is a 10-row hand-tractor drawn planter that can plant ten rows in in one passing (Figure 1). In this study, the environmental performance of planting bulb onion using the MROS in terms of energy consumption and CO_2 emission was assessed and compared with transplanting method.

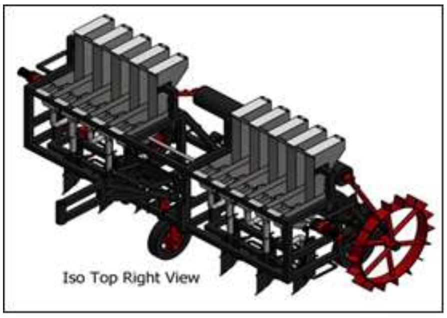

Fig. 1. PHilMech MROS-10 row model seeder

The environmental performance of the MROS and transplanting method were evaluated based on the actual field operations conducted by the onion farmers. This study designated four locations as experimental areas, with each location divided into two sections: one for implementing MROS as planting method and the other for employing the transplanting method. Each experimental area covered at least 2000 m^2. The four locations were treated as replication trials. All the inputs utilized in each farm area were gathered and recorded. This included farm operations and activities from land preparation, planting, crop management, harvesting and packaging before marketing (Figure 2).

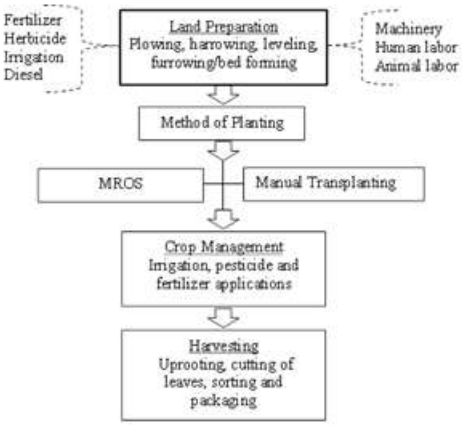

Fig. 2. Systems boundary used in the assessment

B. *Assessment of energy input in onion production*

The machinery, human labor, fuel, fertilizers, and pesticides were specified as inputs to estimate the amount of energy usage while the onion yields as output. The amount of each input was multiplied with the energy coefficient equivalent to calculate the energy use per hectare. The energy input of each system was examined as direct and indirect, renewable, and non-renewable forms of energy. Energy indicators such as energy productivity (EP) and specific energy (SE) were determined using equations 1 and 2, respectively.

$$EP = \frac{Onion\ yield\ (kg/ha)}{Energy\ input\ (MJ/ha)} \quad (1)$$

$$SE = \frac{Energy\ input\ (MJ/ha)}{Onion\ yield\ (kg/ha)} \quad (2)$$

C. *Estimation of CO2 enissions in onion production*

The amount of GHG emissions from inputs in onion production per hectare were calculated by using emission coefficient of chemical inputs such as diesel, fertilizer, pesticide and others. GHG emission can be calculated and represented per unit of the land used in crop production, per unit weight of the produced yield and per unit of the energy input or output (Soltani et al., 2013).

The amount of CO_2 produced was calculated by multiplying the input application rate per unit area (e.g. diesel fuel, chemical fertilizer, pesticide, etc.) by its corresponding gas emission coefficient. For irrigation water, the energy consumption was converted to the amount of fuel consumed and the total CO_2 emission in water irrigation was calculated by multiplying the fuel consumption by its GHG coefficient.

III. RESULTS AND DISCUSSION

A. *Input Energy*

The input energy of onion production system using MROS as planting method compared with transplanting method is summarized in Table 1. The total energy inputs in onion production using MROS was lower at 27,168.06 MJ/ha compared to the system using transplanting method at 30,678.46 MJ/ha due to the reduction of human labor and diesel fuel in crop seedling production and transplanting of seedlings. Majority of the total inputs were contributed by chemical fertilizer and diesel fuel for both the production systems. Similar results have been observed in the production of sweet potato (Flores et al., 2016a), corn (Flores et al., 2016c; Yousefi et al., 2014), eggplant (Flores et al., 2016b), sugar beet (Asgharipour et al., 2012), wheat (Singh et al., 2007) where chemical fertilizer, specifically nitrogen had the highest share in the total input of the crop production.

TABLE I. Energy equivalents of inputs utilized in onion production

Inputs	Method of planting		Difference
	MROS	Transplanting	
1. Human labor	175.09	692.93	(517.83)
2. Machinery	3,287.74	2,998.38	289.36
3. Diesel	7,846.16	11,179.67	(3,333.52)
4. Chemical fertilizer	13,459.70	13,459.70	-
5. Chemical pesticides	1,821.6	1,821.60	-
6. Planting seed	88.20	70.56	17.64
7. PET mesh bag	489.57	455.62	33.95
Total Input, MJ/ha	27,168.06	30,678.46	(3,510.39)

B. *Analysis of energy indicators in onion production*

The total energy consumption, energy productivity and specific energy of the two onion production systems are enumerated in Table 2. Higher specific energy value of 2.18 MJ/kg was calculated for production system using transplanting method compared to 1.82 MJ/kg, for system using MROS mainly because of the additional energy input of diesel fuel during crop seedling establishment and human labor in transplanting method. Aside from this, the mean yield obtained using MROS was higher at 14,930 kg/ha compared to transplanting method at 13,900 kg/ha. Thus, the energy productivity value of transplanting system (0.459kg/MJ) was lower compared to MROS system (0.548 kg/MJ). This indicated that using MROS as planting method would lead to lesser energy requirements to produce a kilogram of bulb onion compared to transplanting method.

TABLE 2. Energy equivalents of inputs utilized in onion production

Energy Indicators	Method of planting		Difference
	MROS	Transplanting	
Average Yield (kg/ha)	14,930	13,900	1,030
Total Input (MJ/ha)	27,168.06	30,678.46	(3,510.39)
Energy productivity (kg/MJ)	0.548	0.459	0.09
Specific energy (MJ/kg)	1.82	2.18	(0.36)

C. *Energy form in onion production*

The forms of energy in the onion production systems were classified into direct and indirect or renewable and non-renewable energies which are presented in Table 3. The share of indirect energy form for production system using MROS was higher at 70% than the production system using transplanting method at 61%. The increase however in direct energy form for system using transplanting method was attributed to the additional use of diesel fuel in land preparation and irrigation for seedling production. Majority of the total energy of both onion production systems was non-renewable energy ranging from 97.5 to 99.03 percent while the remaining renewable energy input ranged from 0.97 to 2.5 percent.

TABLE 3. Forms of energy inputs in onion production

Forms of energy (MJ/ha)	Method of Planting			
	MROS	(%)	Transplanting	(%)
Direct Energy [a]	8,021.25	29.5	11,872.60	38.7
Indirect Energy [b]	19,146.81	70.5	18,805.86	61.3
Renewable Energy [c]	263.29	0.97	763.49	2.5
Non-renewable Energy [d]	26,904.77	99.03	29,914.97	97.5

[a] Includes human labor, diesel
[b] Includes machinery, planting seeds, chemical fertilizer, chemical pesticide, packaging
[c] Includes human labor, planting seeds
[d] Includes diesel, chemical fertilizer, chemical pesticide, machinery, packaging

D. *CO_2 emissions in onion production*

The estimated total CO_2 emission of onion production system using MROS and transplanting method was 2739.94 and 2887.70 kgCO_2eq ha-1, respectively (Table 4). Lower CO_2 emission was obtained for system using MROS compared to that of using transplanting method, because of the additional input of diesel fuel during crop seedling establishment which replenished the CO_2 emissions for machinery and PET mesh bag due to additional yield of using MROS. The results indicated that the production of a kilogram of onion using transplanting method would lead to a 0.208 kg CO_2eq and reduced to 0.184 kgCO_2eq when using MROS because of the reduction in energy input. This implies that the use of MROS as planting method would lead to lesser emission of greenhouse gases in onion production system.

TABLE 4. Energy equivalents of inputs utilized in onion production

Environmental Indicators	MROS	Transplanting	Difference
Diesel	595.93	849.12	(253.19)
Chemical fertilizer			
Nitrogen -N	454.60	454.60	-
Phosphorus-P2O5	89.33	89.33	-
Potassium -K2O	47.32	47.32	-
Chemical Pesticide	95.4	95.4	-
Machinery	233.43	212.88	20.55
PET mesh bag	1223.93	1139.05	84.88
Total kg CO_2eq ha^{-1}	2739.94	2887.70	(147.76)
kgCO_2eq kg^{-1} of Onion	0.184	0.208	(0.024)

IV. CONCLUSION AND RECOMMENDATIONS

The study evaluated the environmental performance of PHilMech MROS and compared it with the existing transplanting method of onion production in Iloilo Province. Based on the evaluation, the onion production system using MROS has lower input energy and CO_2 emissions than using the transplanting method. The level of dependence on non-renewable forms of energy for both the onion production systems was generally high. The introduction of organic farming and the use of renewable input resources are encouraged to reduce the use non-renewable resources and promote sustainable agriculture.

The findings of the study highlight the potential benefits of adopting the MROS for bulb onion planting. The MROS can be a viable alternative planting technology that addresses the need for large quantity of labor during planting. This technology allows the farmers with relatively larger farm areas to schedule planting without being constrained by labor availability. The adoption of MROS can contribute to environmental sustainability by minimizing input energy and reducing CO_2 emissions. By mechanizing onion planting, MROS not only improves operational efficiency but also helps reduce the environmental impact associated with traditional transplanting method.

ACKNOWLEDGMENT

The authors gratefully acknowledge the Philippine Center for Postharvest Development and Mechanization for funding and support in the successful conduct of this research.

REFERENCES

[1] Antolin MCR, Dela Cruz RSM, Flores ED, Neric CF Jr, Corpuz MGA and Pagaduan KRS. 2018. Pilot testing of mechanized onion planting system using 10-row hand tractor driven mechanical seeder. Terminal report. Philippine Center for Postharvest Development and Mechanization. CLSU Cmpd. Science City of Muñoz, Nueva Ecija.
[2] Asgharipour MR, Mondani F, Riahinia S. 2012. Energy use efficiency and economic analysis of sugar beet production system in Iran: a case study in Khorasan Razavi province. Energy; 44:1078–84.
[3] Erdal G, Esengun K, Erdal H, Gunduz O. 2007. Energy use and economic analysis of sugar beet production in Tokat province of Turkey. Energy 32:35–41.
[4] Flores, E. D., R. SM. Dela Cruz, and M. C. R. Antolin. 2016a. Energy use and CO2 emissions of sweet potato production in Tarlac, Philippines. Agricultural Engineering International: CIGR Journal, 18(3):127-135.
[5] Flores E. D., R. S. M. D. Cruz, M.C. R. Antolin. 2016b. Environmental performance of farmer-level corn production systems in the Philippines. Agricultural Engineering International: CIGR Journal, 18 (2):133-143.
[6] Flores, E.D., R. S. M. Dela Cruz, and M.C. R. Antolin. 2016c. Energy use and CO2 emissions of eggplant production in the Philippines. Agricultural Engineering International: CIGR Journal, 18(1):138-148.
[7] Flores ED, Dela Cruz RSM, Antolin MCR, Neric CF Jr and Corpuz MGA. 2018. Laboratory and Field Testing of 10-Row Onion Mechanical Seeder. Terminal report. Philippine Center for Postharvest Development and Mechanization. CLSU Cmpd., Science City of Muñoz, Nueva Ecija
[8] Gavino R.B., V.E.B. Camaso, C.C. Tiw-an. 2020. Assessment of mechanization level of onion production in Nueva Ecija, The CLSU International Journal of Science and Technology, 4(1):82-99
[9] Ghorbani R, Mondani F, Amirmoradi S, Feizi H, Khorramdel S, Teimouri M, Sanjani S, Anvarkhah S, Aghel H. 2011. A case study of energy use and economic analysis of irrigated and dry land wheat production systems. Appl Energy; 88:283–288.
[10] Khoshnevisan B, Rafiee Sh, Omid M, Yousefi M, Movahedi M. 2013. Modeling of energy consumption and GHG (greenhouse gas) emissions

in wheat production in Esfahan province of Iran using artificial neural networks. Energy; 52:333–338.

[11] PSA.2019. Philippine Statistics Authority. Volume and Area of Onion Production. Accessed at http://www.bas.gov.ph. Retrieved on July 2020.

[12] Singh H., Singh A.K., Kushwaha H.I., Singh A. 2007. Energy consumption pattern of wheat production in India. Energy. 32:1838-1854.

[13] Soltani A, Rajabi MH, Zeinali E, Soltani E. 2013. Energy inputs and greenhouse gases emissions in wheat production in Gorgan Iran. Energy; 50:54–61.

[14] Uhlin H. 1998. Why energy productivity is increasing: an I-O analysis of Swedish agriculture. Agric Syst; 56(4): 443-65.

[15] Yousefi M., Damghani A.M., Khoramivafa M. 2014. Energy consumption, greenhouse gas emissions and assessment of sustainability index in corn agroecosystems of Iran. Science of the Total Environment. 493: 330-335.