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Research Article

Energy Involvement in Operating a Gasoline Engine Powered Weeder under Direct and Indirect Exhaust Fume Exposure of an Operator in the Field

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Abstract

Sufficient energy is needed for agricultural productivity in the farm. Planning is needed for effective energy consumption since the demand for food in satisfying the world population is increasing every day. This study was carried out in order to determine the direct energy consumed by an operator in a field during weeding operation using a gasoline engine powered weeder. The test was carried out in two ways, first by exposing the operator to the exhaust fume of the gasoline engine and secondly by channelling the exhaust fume away from the operator. All test parameters taken in both experiments were taken under same operator and field dimension. The size of the field used in each experiment was 5 m by 46 m. The experiment was replicated 10 times. The results of the energy analysis obtained in this study showed that the specific direct energy of 0.1307 $MJha^{-1}$ and 0.1604 $MJha^{-1}$ were obtained under indirect and direct exposure of the weeder engine, respectively. Following the same trend of presentation above, the labour energy obtained for both experiments carried out were 12 $MJJha^{-1}$ and 42 $MJJha^{-1}$, respectively. Test results also showed that the energy spent in the operation of a protected working environment for both operational time and idle time were much less when compared with that of an unprotected working environment for same operational time and idle time.

Keyword: Energy, Performance. Fume, Field, Weeder

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Introduction

Sufficient energy to perform a work in its right form and at the right time is needed in crop production. One way to improve energy consumption in agriculture is to determine the efficiency of the methods and techniques used. According to FAO (2001), energy requirement is the amount of food energy needed to balance energy expenditure in order

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to maintain body composition and a level of the necessary and desirable physical activity consistent with long term good health. Energy balance is achieved when the input (dietary intake) is equal to output (energy expenditure) plus the energy cost of body growth. When the balance is maintained for a prolonged period, the individual is considered to be in a steady state to satisfy the demands imposed by the society and the environment. It is important to know the various indicators associated with the cost of owning and operating farm implement to enable a farmer know if he/she is making profit or loss in the farm business by using the implement (Oluka, 1998).

An experienced farmer endeavours to utilize in full capacity the agricultural mechanism such as farm machinery in order to optimize production at reduced cost (Yahanna and Ifem, 2003). The constraint of rapid growth of food production in the agricultural sector seems to be mainly that of low crop yields and resource productivity. The reality is that Nigeria has not been able to attain self-sufficiency in crop productions despite the increase in hectares that are put into production annually (Faleye et al., 2013). There is a dearth data on energy expenditure and returns in crop production in Nigeria and other developing countries (Abubakar and Ahmed, 2010). Though much attentions are not given to the knowledge about energy expenditure in crop production in Nigeria, because of the increased demand for food production to meet the pressures from the ever increasing population that make the energy – agriculture relationship very important. One way to optimize energy consumption in agriculture is to determine the efficiency of methods and techniques used (Kitani, 1999; Safa and Tabatabaeefar, 2002).

Olaoye et al. (2012) mentioned some factors that made weeding so important that the energy used in doing the work should not be neglected. These factors include: a.) weeds waste excessive proportion of famers' time, which act as a brake to development. b) weeding which is important, but equally a labour intensive agricultural unit operation. c.) uncontrolled weeds reduce yield of principal crops. d.) farmers use traditional tool which are labour intensive. That is why crop – yield is directly proportional to the energy input (Srivastava, 1982). Despite the importance of energy use as emphasized by Olaoye et al. (2012), it was observed in the works of Parida (2002); Yadav and Pund (2007); Mohammed (2011); Nkakini and Abu (2015); Olaoye and Adekanye (2011); and Kamal et al. (1999) which all centred on weeder development that none of them dealt with energy involvement during weeding operation. In order to know the energy involvement during weeding activity at the National Centre for Agricultural Mechanization (NCAM), Ilorin, a field test was conducted using a gasoline powered mechanical weeder for comparing the energy expenditure of a single operator subjected under direct and indirect exposure of the gasoline powered mechanical weeder exhaust fume.

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Materials and Methods

The work was carried out at the research field of the National Centre for Agricultural Mechanization (NCAM), Ilorin, Kwara State. The Centre is located at Longitude 4^0 30E and Latitude 8^0 26N which is 370 m above sea level under the guinea savannah vegetation on a sandy loam and clay loam soil. The field has a dimension of 5 m by 46 m which it is in two parts (A and B). The moisture content of the soil under field test was 10.42% on dry basis. The weeder is powered by a 1.25 kW gasoline engine. It is characterized by a single cylinder which is air cooled. It is the hand cracking type. It has two pneumatic wheels that serves for transport and support purposes. It has a working width of 35 cm. The exploded drawing of the weeder is shown in Figure 1. Shown in Figures 2 and 3 are the pictures of a gasoline weeder where one was operated with its exhaust pipe exposed to the operator while the other one was when the exhaust pipe was channelled to the ground. The same parameters were measured for the two experiments carried out.

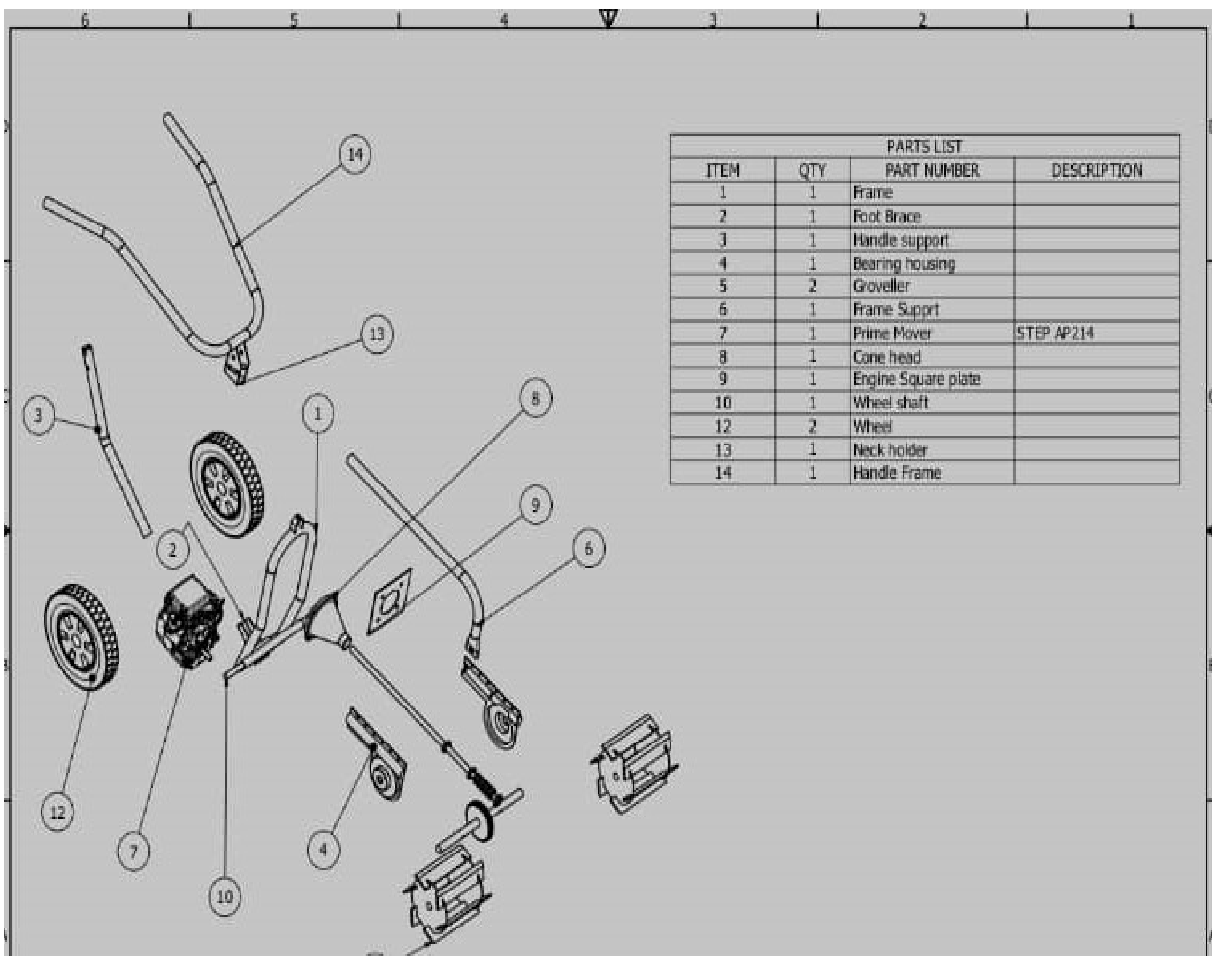

Figure 1. Exploded view of the weeder used

Figure 2. Mechanical weeder with protected exhaust pipe

Figure 3. Mechanical weeder without protected exhaust pipe

Energy analysis was done based on work output on the field that involves weeding operation. The direct energy (human labour) used for the field operation was calculated using the expression given by Moerschner and Gerowitt (2000) as:

$$ED = h \times AFU \times PEU \times RU \quad (1)$$

where,

ED = Specific direct energy use (fuel) for a field operation, MJ ha^{-1}.
h = Specific working hours per run, h ha^{-1}
AFU = Average fuel use per working hour, L h^{-1}
PEU = Specific energy value per litre of fuel, MJ L^{-1}
RU = Runs, number of applications in the considered field operation.

The labour energy input (MJha^{-1}) at every stage in the weeding process was estimated using the expression given in Equation (2) as:

$$LABEN = \frac{LABOUR\ X\ TIME}{AREA}\ x\ LABENF \quad (2)$$

where,

LABEN = labour energy, MJ ha^{-1}
LABOUR = number of working labourers
TIME = operating time, h
AREA = operating area, ha
LABENF = labour energy factor, MJ h-1(i.e. 1-1.5)

The field efficiency of the weeder was determined using the expression given in Equation (3) as:

$$Field\ efficiency\ \% = \frac{Effective\ field\ capacity}{Theoretical\ field\ capacity}\ x\ 100\% \quad (3)$$

Where,

$$Effective\ field\ capacity \left(\frac{ha}{h}\right) = \frac{total\ area\ cultivated\ (ha)}{total\ work\ time\ (h)} \quad (4)$$

and

$$Theoretical\ field\ capacity \left(\frac{\mathrm{ha}}{\mathrm{h}}\right) = \frac{\text{mean working width (cm) x mean speed}\left(\frac{\mathrm{m}}{\mathrm{s}}\right) x\ 36}{10000} \quad (5)$$

This formula was used in computing the data presented in Tables 1A and 1B.

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Table 1. Field data obtained during performance evaluation of a gasoline engine powered weeder

A				B			
Operational time (secs)	Turning time (secs)	Idle time (secs)	Total time (secs)	Operational time (secs)	Turning time (secs)	Idle time (secs)	Total time (secs)
92	6	10	991	91	6	152	3451
85	5	12		85	7	527	
85	5	20		87	8	799	
75	5	40		100	8	822	
65	6			103	8		
75	6			109	8		
82	5			92	6		
77	5			107	7		
81	5			92	8		
68	5			109	8		
71							

Note: Data in A was obtained when the operator was unexposed to the exhaust fume of the gasoline engine of the weeder. Data in B was obtained when the operator was exposed to the exhaust fume of the gasoline engine of the weeder

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For the purpose of this study, the idle time as contained in Tables 1A and 1B was the time it took the operator to remove the debris and thread weed that clustered around the weeder's blades. While operational time was the time involved in doing the main field operation.

It should also be noted in this study that the specific direct energy values obtained for both operations where the operator was unexposed and exposed to the prime mover's exhaust fume were 0.1307 $MJha^{-1}$ and 0.1604 $MJha^{-1}$, respectively. Likewise, the labour energy used for operations A and B using the expression given in Equation (2) gave 12 $MJha^{-1}$ and 42 $MJha^{-1}$, respectively.

CONCLUSION

The energy indicators and the field efficiencies showed that the operator working under direct exhaust fume exposure tend to put more energy in an certain area of field work but produce less output at an extended time. While the other operator working under indirect exhaust fume exposure, used little energy to produce more output at a shorter time on the same area of plot. And on the health aspect, the operator working under direct exhaust fume exposure may acquire some health issue that may not be good for his body than the operator working under indirect exhaust fume exposure.

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