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Design of a Row Crop Weeder

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Abstract
The operations involved in the crop production cycle include land clearing, land forming/ land leveling, tillage, and crop establishment, harvesting and post harvest operations. Crop establishment is necessary to eliminate the effect of weeds, pests and disease infestation and to provide suitable conditions for optimum yield. More than 3000 species of weeds had been identified all over the world. The cost of weed management is enormous, however the opportunity cost of weed management is higher. Weed control measures must be put in place to check the growth and propagation of weeds. Chemical and manual weed control methods are viable alternatives; however, whereas environmental impact of herbicides made chemical method unsustainable, drudgery limits the size of farm of an individual in sub-Saharan Africa. Introduction of an effective mechanical weeder is expected to encourage subsistent farmers leading to increased production and hence reducing poverty. To achieve this objective, a row crop weeder was developed in the Federal University of Technology, Akure in Nigeria. The weeder was designed, fabricated and tested and found to be very efficient. The machine consists of an abrasive nail- brush mounted on a shaft, transmission system, 5Hp engine, frame and wheels. The height of cut of the machine is adjustable, thus the machine operates as a mower when cutting height is 2 cm to 4 cm above the ground level, but works effectively as a weeder between –2 cm to 1 cm. The machine is simple, cost effective and useful for small to medium scale farm holders. It is also a positive step towards reduction of drudgery involved in row crop weeding. Zero tillage, conventional tillage (with plough and harrow) and other cultural tillage practices that would present crops on the flat are well suited for the adoption of this machine. The cost of the prototype machine was estimated at 500 US Dollars (N 65,000.00). However the cost of the commercial model was estimated at 300 US Dollars (N39, 000.00). The machine is economically viable with fuel consumption limited to 8 litres per day.

Keywords: *Drudgery, food security, mechanical weeding*

Introduction
Weed infestation on Nigerian soils is quite high particularly during the raining seasons when soil moisture is high and plant growth conditions are optimum. The higher competitive nature of weeds compared to crops is posing serious threat to crop yield. Weeds can cause severe damages to the farming enterprise. These include: decrease in crop yield, impairment of crop quality, harbouring of plant pests and diseases, increase in irrigation costs, injury to livestock and decrease in land values. Oni (1990) reported that 50 to 70 % of yield reduction is caused by poor weed control. Utilisation of hand tool technology is one of the major causes of poverty in the

rural areas. Nganilwa et al. (2003) opined that a farmer using only hand hoe for weeding would find it difficult to escape poverty, since this level of technology tends to perpetuate human drudgery, risk and misery. The operations involved in the crop production cycle include land clearing, land forming/land leveling, tillage, and crop establishment, harvesting and post harvest operations. Crop establishment is necessary to eliminate the effect of weeds, pests and disease infestation and to provide suitable conditions for optimum yield. More than 3000 species of weeds had been identified all over the world. The cost of weed management is enormous; however the opportunity cost of weed management is higher, Rangasamy et al. (1993) reported that one third of the total cost of cultivation is spent on weeding. The methods employed to remove weeds on the farm include flaming, desiccation, manual and mechanical weeding. Manual weeding is common in Africa particularly in Nigeria where about 75 % of the population is engaged in farming. This method is labour intensive and is one of the major problems of farming in Nigeria. The resultant effect is that youths detest farming and engage in rural- urban migration in search of greener pastures. Mechanical weeding is not yet introduced in Nigeria, as there are no effective row crop weeders. In developed countries chemical weeding is more prominent than mechanical weeding. However in the recent times the problem of environmental degradation and pollution is making the world to have a re-think on the adoption of mechanical weeders. Busari (1996) opined that the use of herbicides has possible effect on desert encroachment and other adverse environmental impact. Development of row crop weeders is the viable option in order to ensure sustainable crop production and optimum environmental conditions. It is very easy to use ploughs, harrows and mowers to control weeds in the open field where crop had not been planted. However special care must be taken when using weeders in row crop plantations. Previous research efforts at the Federal University of Technology Akure, Nigeria have yielded some results. Ademosun et al. (2003) reported the development of various machines for weeding and harvesting. Previous efforts in this area are quite appreciable but the research efforts are yet to be adopted by farmers in Nigeria. One of the major problems with existing designs is that the manual power required to move the machines and propel the operational components of these machines is high probably making these designs un-adoptable by farmers. Power requirement is generally high for soil engaging equipments (Olukunle, 1995). Yet manual power available on the farm is limited to 0.1 kW (Kaul and Egbo, 1985).

Materials and Methods

The force required to uproot some weeds were determined by using thread attached to the weed, the thread was pulled through a spring balance and the force at the point of weed removal was recorded. The machine (Fig. 1) was designed based on the principle of weed stem failure due to shear, and soil /root failure due to impact and abrasion. The machine was tested at various brush and auger speeds. Functional efficiency (weeding efficiency) was determined by removing (manually) the weeds in 1 m x 1 m area of the farm, the weeds were weighed and recorded. The process was repeated in ten randomly selected locations on the farm. The average weight of weeds in 1 m x 1 m area on the farm after one pass of the weeder through the farm was deducted from the actual weight of weeds in 1 m x 1 m area. Thus functional efficiency was determined from the relation:

$$\text{Functional efficiency} = \frac{(\text{Actual weight of weeds} - \text{Weight of weeds left on the farm})}{\text{Actual weight of weeds}} \times 100$$

Results and Discussion

The machine was designed, fabricated and tested at the Department of Agricultural Engineering, Federal University of Technology, Akure, Nigeria in March, 2006. The machine has a width of cut, 50cm and a field capacity of 0.075 ha/h or 0.60 ha/8 working hours of the day. Thus two operators with two weeders would conveniently weed a hectare of farmland in one day. Average

field efficiency was 90% and the functional efficiency was between 90 and 98.5%. The machine performed best as a mower between cutting heights of 2 cm to 4 cm and works well as a weeder between 2 cm below ground level and 1cm above the ground. Some cultural practices, which involve ridges and heaps, are not well suited for the use of the machine. However, conventional tillage, minimum tillage and zero tillage are well suited for the mechanization of weeding operations. The cost of the prototype machine was estimated at 500 US Dollars (N65,000). However the cost of the commercial model was estimated at 300 US Dollars (N39,000). The machine is economically viable with fuel consumption limited to 8 litres per day. Fig.2 shows the effect of Brush and forward speeds on weeding efficiency, results show that weeding efficiency was consistently higher with increase in brush speed and consistently lower with increase in forward speed. Although, higher forward speed enhances machine field capacity, duration for weed processing/removal is reduced as the machine browse through the field. Thus, a compromise between brush speed and machine forward speed is required in order to optimize the process. Forward speeds of 0.25 to 0.5 m/s and brush speeds of 2000 to 3000 rpm resulted in weeding efficiency (functional efficiency) of 94.8 to 97.5 %. An operator working at an average forward speed of 0.25 m/s would complete a hectare in 18.52 hours (a work rate of 0.0504ha/h). At higher speed of 0.5 m/s the operator could complete a hectare in 9.26 hours (a work rate of 0.108 ha/h).

Conclusion

A row crop weeder was designed, fabricated and tested at the Department of Agricultural Engineering, Federal university of Technology, Akure. The machine though designed, as a weeder was adapted as a mower for a variety of grasses. The machine performed excellently as a weeder and as well as a mower. It works as a mower when cutting height is between 2 cm and 4 cm, however it works well as a weeder between cutting height of 2 cm below the ground and 1 cm above the ground level. The machine would be very useful for peasant farmers as well as small to medium scale farm holders. The cost of the commercial model of the machine was estimated at 300 US Dollars (N39,000). It is economically viable with fuel consumption limited to 8 litres per day. The machine performed excellently between forward speeds of 0.25 m/s and 0.5 m/s and between brush speeds of 2000 rpm and 3000 rpm.

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Fig. 1 The Row Crop Weeder

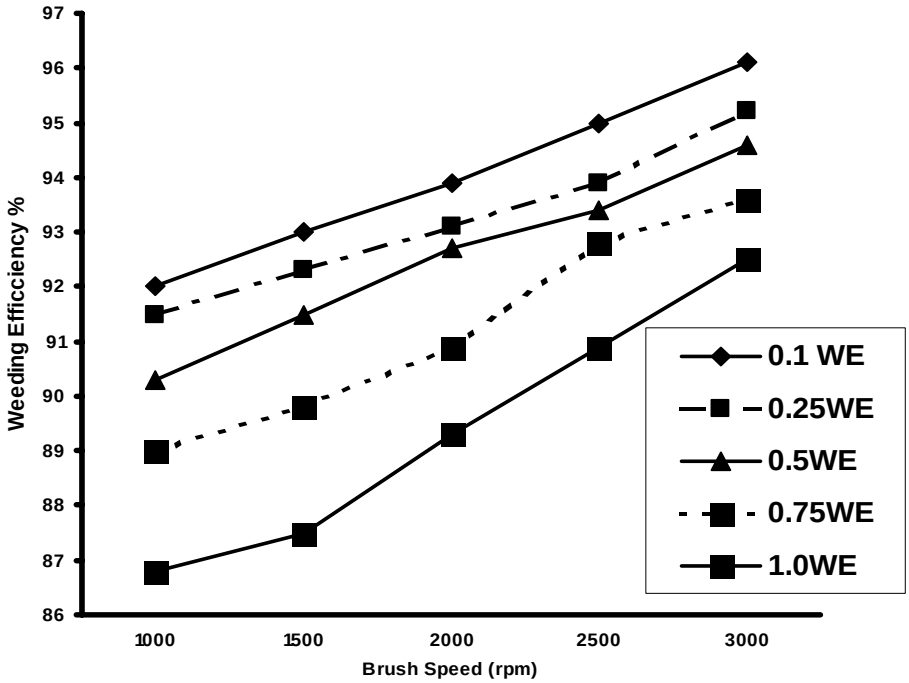

Fig.2 : Effect of Machine Forward Speed and Brush speed on Weeding Efficiency at 18 % Moisture Content