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Development of a harvester for *amaranthus* vegetable

Agbetoye[a], Leo and Oladipo, Oyeneye[b]

a,b Department of Agricultural Engineering, Federal University of Technology, Akure, Ondo State, Nigeria. E-mail: lasagbetoye@yahoo.com

Abstract

In Nigeria, leafy vegetables had been mostly cultivated and harvested manually by subsistence farmers. Manual harvesting involve a lot of drudgery, hence with small-scale farmers in mind, a low cost leaf vegetable harvester was designed and evaluated for performance in harvesting *Amaranthus sp.* The main components of the machine are the frame, the reciprocating blade which cuts the vegetables at a predetermined height above the soil. The machine was powered by a petrol engine rated 3 kW, 1440 rpm and the forward momentum was provided by the pushing action of the operator. The performance of the harvester was evaluated in harvesting *Amaranthus specie (Arowojeja)* under various crop, soil and operational parameters. The parameters include moisture content of the soil, crop density, working width and the operating speed of the operator. The result of the tests performed on the machine shows that it is appropriate for adoption by small scale farmers. Furthermore, it shows that the field efficiency of the machine was influenced more by the moisture content of the soil in the furrows rather that the moisture content of the bed, the speed of the operator and the stage of crop development of vegetable prior to the time of harvesting. The optimum field capacity, harvesting efficiency, collection performance efficiency of 0.07 ha/hr, 71.5%, 68.3% respectively were obtained at operator speed of $0.27 ms^{-1}$ and crop density of 1,190,311 plants/ha

Keywords: *Amaranthus,* harvester, field capacity, harvesting efficiency, collection efficiency

1. Introduction

Harvesting constitutes a major operation among agricultural activities. Harvesting of *amaranthus* vegetables is usually carried out very early in the morning with the objective of maintaining the full turgidity of leaves and other fleshy part of the plant, since transpiration is normally at minimum during the dark and early hours of the day. This is the optimum time to harvest fleshy or succulent crops which ideally will remain fresh until they are either consumed or sent to market. Vegetables are harvested for some components of their vegetative (celery, spinach, *amaranthus*) or reproductive (tomato, broccoli) structure. *Amaranthus spp.* is alternatively named African spinach, Indian spinach, bush greens, green leaf, spinach greens, bonongwe. There are many other species of *Amaranthus spp*. in cultivation but *Amaranthus Caudatus, Amaranthus Cruentus* (grain), *Amaranthus Hypochondriacus* and *Amaranthus tricolor* (vegetables) are the most widely grown in Africa and are particularly important in west Africa (George, 1985). All the above species are short-lived annuals growing to 1m in height. *Amaranthus spp.* is a plant with an upright growth habit cultivated for both its seed which are used as a grain and its leaves which are used as vegetables. Both the seeds and the vegetables contain protein of an unusual high quality (Bressani, 1990) and high percentage of vitamin and mineral. The National Academy of Science lists amaranths (vegetable) as one of 23 food plants that could be used to improve nutrition and the quality of life for people in developing countries.

Due to the geometrical increase in the world population there is increasing need to devise suitable methods and processes for development of food production in the world in order to ensure the availability of food all round the year. *Amaranth spp.* being easily grown, contain more vitamins and minerals and fewer calories than most vegetables, its ability to do well under cool conditions and be eaten at any stage of maturity, which makes them ideal for regions with short growing season has necessitated the increasing interest in leafy *amaranth* in the international community.

Researches on *amaranths* are on the increase in Nigeria, according to {OSADP 2003}; many individuals and Osun State Ministry of Agriculture have embarked on large scale production of the vegetable employing women (most of which, work at subsistence level) to harvest at maturity. Likewise researches are initiated by research institutes on dry season cultivation of leafy vegetables (fruit inclusively) under different irrigation methods in Nigeria.

Convectional method of reaping *amaranthus spp.* in Nigeria is too labour –intensive and time-consuming since a lot of drudgery is involved in the manual harvesting of *amaranthus*, with a harvesting rate of over 120 man-hour per hectare (Anonymous, 1984). Consequently, mechanized method of harvesting in large and medium scale agriculture is desirable to saves time, minimize labour requirement and reduce drudgery and to meet market demand.

The objectives of the project are:

i. To design a medium scale *Amaranthus spp.* harvester
ii. To fabricate an experimental prototype of the machine
iii. To carry out the performance evaluation of the experimental prototype harvester

2. Machine design and fabrication

2.1 Description of the Amaranthus harvester

The assembly drawing of the harvester is shown in Figure 1 while Figure 2 shows the machine being used to harvest. The components include the frame, collecting tray, blade, hood, handle and wheels.

Fig. 1: Picture of the harvester

Fig. 2: Picture of the harvester in operation

2.2 Design Considerations

The vegetable harvester employed the principle of cutting and shearing in its design due to the consideration that the plants have the tendency of re-growing the vegetative parts of the plants again. Other design considerations are:

i. The machine was fabricated using locally available materials so as to make the machine affordable by farmers
ii. The frame was rigid and of adequate strength to support the weight of the entire components and especially that of the collecting tray and harvester blade that project sideways from the frame.
iii. The collecting tray was tilted at 8^0 from the horizontal. This in conjunction with the vibration of the collector prevents the vegetable from slipping off the collecting tray.
iv. The collecting tray was made up of light weight material in order to reduce the weight burden on the frame and maintain stability.
v. The machine frame, shape and size were fabricated in such manner that permit the movement of the machine in between the beds.

3. Results and discussion

The results of the tests performed with the harvester in harvesting *amaranthus* vegetable is as presented in Figures 3 to 10

3.1 Field Capacity

Field capacity of the machine varied between 0.034 ha/h and 0.071 ha/h (Figs. 3 to 10), while the maximum field capacity was obtained when the moisture content of the soil plied was 21.1% and that of the bed was 24.6%. The field capacity of the machine is lowest at a moisture content of 31.5% having a value of 0.034 ha/h. This is due to reduction in traction between the wheels and the soil. Figure 3 shows that the field capacity varies inversely as the moisture content of the spaces plied. The field capacity increases when the crop density increases from about 263000 Plants/ha to 119000 Plants/ha (Fig. 5). The optimum speed for operating the machine is 0.27 ms^{-1} (Fig. 6).

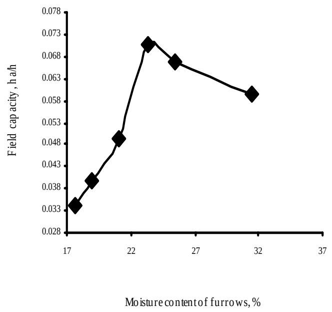


Fig.3: Field Capacity against moisture content of furrow Spaces

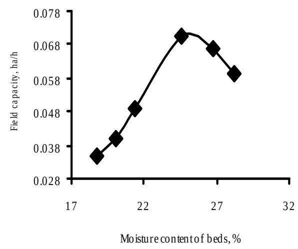


Fig.4: Field Capacity Vs Moisture Content for against Moisture Content for the Beds

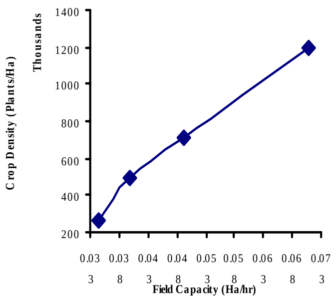


Fig.5: Field capacity against crop density

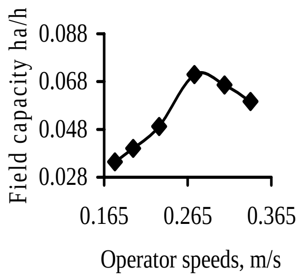


Fig. 6: Graph of field capacity against operator speed

3.2 Harvesting Efficiency

The vegetables harvester has an average harvesting efficiency of 68.02% at the end of the harvesting operation. The quantity of vegetable harvested was maximum when the soil moisture content of the space plied was 21.1%. As shown in Fig….t at a moisture content level of the plied spaces go beyond 21%, the harvesting efficiency reduces. The harvesting efficiency is optimum at maximum crop density of 1190311 plants/ha. It was as a result of more vegetables plant stands between the divider serrated teeth and the serrated harvester blade.

The harvesting efficiency was also affected by the operating speed of the operator, when the operator was moving at a speed of 0.18.ms^{-1}, the efficiency of harvesting was minimum, reaching a maximum value of 71.51% at 0.27 ms^{-1}, before further decreasing to 68.13% at 0.34 ms^{-1} (Fig, 10).

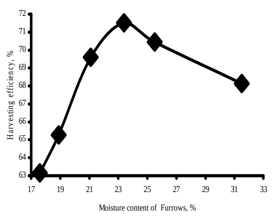
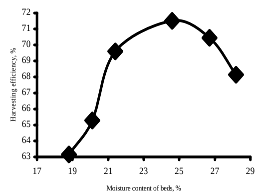


Fig. 7 : Harvesting Efficiency Vs Moisture Content for Plied Spaces



Fig, 8: Harvesting Efficiency against Moisture Content for the Beds

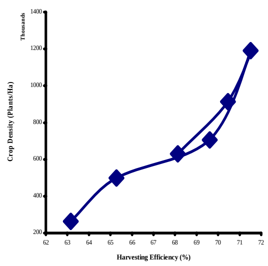


Fig. 9: Harvesting Efficiency against Crop Density

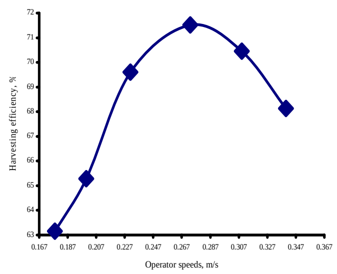


Fig. 10: Harvesting Efficiency against operator speeds

3.3 Collection Efficiency

The quantity of vegetable plant collected on the tray during the harvest period differ in proportion due to the scattering of the cut vegetable plants by the reciprocating movement of the blade during harvest. The efficiency was affected mainly by the operating speed of the operator and the reciprocating speed of the blade. However, more vegetables were collected on the tray at an operating speed of 0.18ms^{-1}. Closely spaced plants also have high collection efficiency.

4. Conclusions

An *amaranthus* harvester for small scale farmer was designed, fabricated and its performance evaluated at different crop densities, moisture content, operating speed and working width for fresh leafy vegetables. The growth parameters; diameter of the stem, plant height and spacing between the plants were found to have effect on the performance of the machine.

The semi automatic machine is affordable and can be acquired by subsistence level farmers. It enhances easy usage and as well as minimizes time lost due to drudgery associated with manual harvesting. The capacity and the harvesting efficiency were found to increase with increase in the working width of the machine. Furthermore, the moisture content of the furrow spaces have an enormous impact on the overall efficiency, though many vegetables are harvested at high crop density. The average field capacity, harvesting efficiency and collection performance efficiency obtained with the machine were 0.0535 ha/hr, 68.0% and 69.5% respectively. The design of the machine can be further improved upon to enhance its performance.

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