RUFORUM Working Document Series (ISSN 1607-9345), 2019, No. 18 (1): 149 - 154.
Available from http://repository.ruforum.org

Research Application Summary

Development and evaluation of manually operated vegetable transplanter for smallholder farmers

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Abstract

Transplanting of vegetable seedlings with obsolete tools such as cutlasses and hoes is one of the greatest constraints to increasing vegetable production in Ghana. It makes the process slow, time consuming and tedious. A simple handheld vegetable transplanter that is affordable and compatible with the farming systems in Ghana was, therefore, designed, constructed and evaluated under local conditions for smallholder farmers. The construction of the handheld vegetable transplanter was done with local materials and technology. The constructed transplanter could transplant accurately at three different transplanting depths of 5 cm, 7.5 cm, and 10 cm. Field performance of the constructed transplanter was evaluated at three different transplanting depths. The results from field eval nation of the transplanted showed that, with transplanting at 5 cm depth, the mean field efficiency was 91 .05%, while at 7.5 cm depth 74.44% efficiency was recorded. Seedlings transplanted at depth 10 cm had the least field efficiency of 51.22% and also recorded the highest plant mortality of 10% afier 20 days of transplanting. From the study, it was realised that the optimum pepper seedlings transplanting depth using this transplanted range from 5 cm to 7.5 cm.

Keywords: Construction design, Ghana, pepper seedlings, transplanting depth, Vegetable transplanted

Résumé

La transplantation de plants de légumes à l’aide d’outils obsolètes tels que des coutelas et des houes est l’une des principales contraintes à l’augmentation de la production de légumes au Ghana. Cela rend le processus lent, long et fastidieux. Un transplanteur de légumes portatif simple, au prix abordable et compatible avec les systèmes agricoles du Ghana a donc été conçu, construit et évalué dans des conditions locales pour les petits exploitants agricoles. La construction du transplanteur de légumes portatif a été réalisée avec des matériaux et des technologies locaux. Le transplanteur construit pouvait transplanter avec précision à trois profondeurs différentes de 5 cm, 7,5 cm et 10 cm. Les performances sur le terrain du transplantoir construit ont été évaluées à trois profondeurs de transplantation différentes. Les résultats de l’évaluation sur le terrain des plants transplantés ont montré que, lors de la transplantation à une profondeur de 5 cm, l’efficacité moyenne sur le terrain était de 91,05 %, tandis qu’à une profondeur de 7,5 cm, l’efficacité était de 74,44 %. Les semis transplantés à une profondeur de 10 cm ont eu la plus faible efficacité au champ de 51,22% et ont également enregistré la plus forte mortalité des plantes de 10% après 20 jours de transplantation. L’étude a montré que la profondeur optimale de repiquage des plants de poivrons à l’aide de cette méthode varie de 5 cm à 7,5 cm.

Mots clés : Plan de construction, Ghana, semis de poivrons, profondeur de repiquage, repiquage de légumes.

Introduction

Vegetables are essential pass of balanced meals and contribute to the nutrition and health of people. Common vegetables grown in Ghana include pepper, tomatoes, onions and okra. In its cultivation, seeds are often nursed into seedlings before transplanting. Transplanting refers to the practice of removing seedlings from nursery and placing them on prepared fields, for them to survive and grow as separate plants (Thorat *et al*., 2017). However, the transplanting process can be tedious and time- consuming. It is a common practice for farmers to transplant vegetable seedlings using hoes and cutlasses ofien resulting to inaccurate transplanting depth and spacing, and also serious backache to farmers. This limits production and leads to untimeliness of operation and yield losses (Amposah *et al*., 2012). There is therefore a need to develop simple and cost-effective tools and equipment that could be used by the smallholder farmer for transplanting vegetable seedlings.

Our literature search indicated that there was very limited local efforts to develop handheld transplanters for farmers in Ghana and in other parts of Africa. However, several works have been done by researchers outside Africa to raise the level of technology associated with vegetable transplanting in small farm holdings. A number of these works have been carried out by researchers in China, India, South Korea and Japan. The very few transplanters available in Ghana were imported from other developed countries and are often automated with high purchasing cost. Thus, resource poor farmers are unable to use them.

Nandede *et al*. (2017) developed a manually operated transplanted and field tested it under Indian conditions. In their design, the authors only considered the pipe for guiding the seedling and furrow opener for introducing it into the soil. The seedling tray was held by the hand and there was no mechanism to control the depth of transplanting. Therefore, the main focus of this study was to develop a manually operated transplanted by taking into consideration a tray holder as well as a seedling planting device with a depth adjuster for smallholder farmers. The transplanted was evaluated in the coastal savannah zone of Ghana using pepper as the test crop. The evaluation focused on effect of depth on transplanting time, field capacity and efficiency and post-transplanting seedling mortality.

Materials and methods

Design and construction of the components of the manual vegetable transplanter. The major objectives of the design of this tool was to address the challenges of backache and waist pain suffered by farmers during transplanting and also to shorten transplanting time. The idea arose after imagining how farmers have to bend throughout transplanting activity when using local tools such as cutlasses and hoes. This challenge was then analysed and it was realised that farmers needed a simple and inexpensive implement that would help alleviate the challenges. The design was based on existing designs with modifications. Sketches were done for each unit component and assembled. The design drawings of the handheld vegetable transplanted was carried out in

AUTOCAD software. The construction of the vegetable transplanter was done at the Cape Coast branch of the GRATIS Foundation division under the Ministry of Innovation, Science and Technology, Ghana. The various components of the transplanter consisted of a seedling guide pipe (cylindrical hollow pipe), furrow opener (jaw), depth regulator/adjuster, adjustment screw, fixed and movable handle, lever, plant spacing marker and seedling table or tray holder.

The seedling table was designed and constructed to hold seedlings in trays to facilitate transplanting in order to solve the problem of bending down to pick a seedling before putting it in the seedling delivery pipe which could be injurious to the health of the farmer through backaches and spinal disorders. The individual components were assembled to obtain the fabricated handheld vegetable transplanter. In this process, a part of the furrow opener was welded to the seedling delivery pipe whilst the other component was attached to the movable handle. The depth regulator was connected to one side of the furrow opener by a bolt and nut, and the plant spacing marker connected to another side of the furrow opener by two long bolts to tighten it. The height of the handheld transplanter from the top to the tip of the furrow opener was 108 cm.. The figures below shows the assembly drawings.

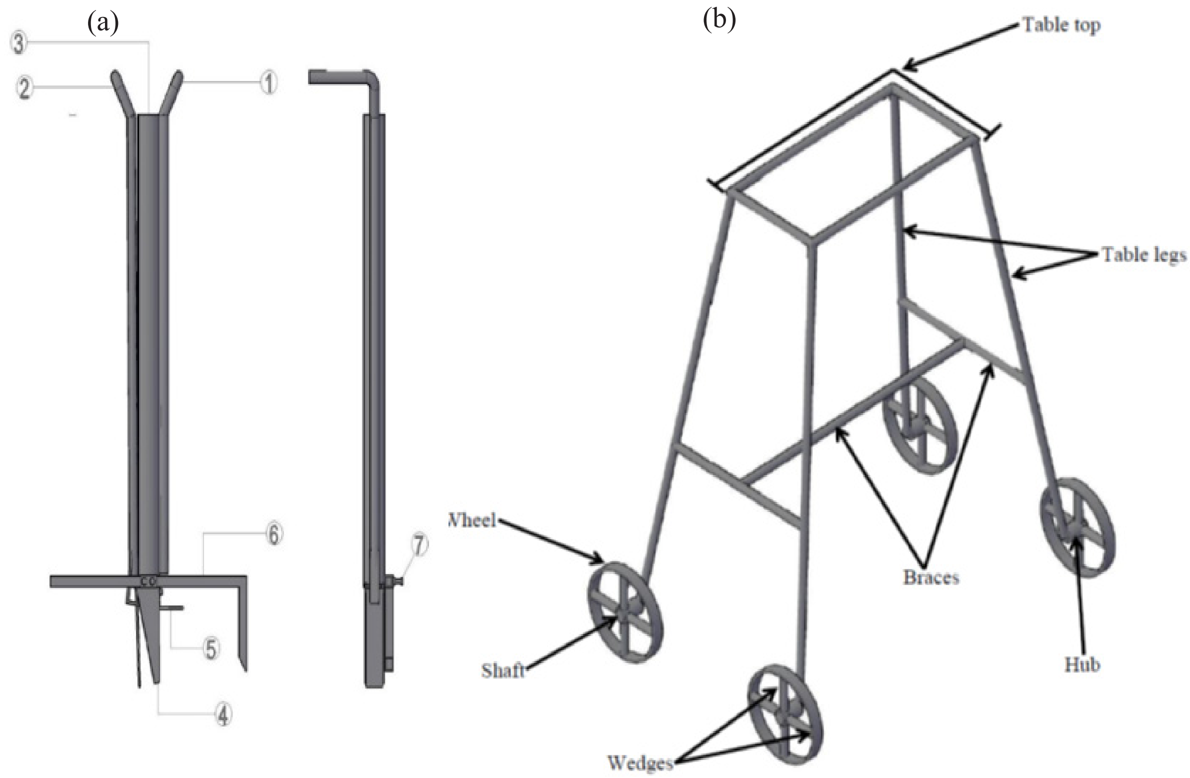

Figure 1. The assembly drawing of the (a) handheld vegetable transplanter and (b) tray holder

Design mechanism and working of the transplanter. The key mechanism used in this transplanting is the lever mechanism. Here, the furrow opener operates in such a way that the movement of the movable handle tends to cause its opening and closing. Thus, the furrow opener is closed and inserted into the soil without the release of the seedl ings. In the next stage, the furrow opener is opened to allow for the creation of the hole and the release of the seedling into the soil.

Field evaluation of the manual vegetable transplanter. The field evaluation experiment was conducted at the School of Agriculture Teaching and Research Farm, University of Cape Coast in the central region of Ghana. According to Owusu-Sekyere *et al*. (2011), the annual temperature is 23.2-33.2°C with an annual mean of 27.6°C and relative humidity is 8 1.3- 84.4. Bell pepper (*Capsicum annuum*) seedlings were used as a test crop. The seeds of bell pepper were nursed in seed nursery trays (two seeds per hole) filied with cocopeat as growth media. The seeds germinated five days after nursing. The seedlings were given proper care until they reached transplanting stage six weeks after nursing. The field was ploughed using a disc plough and then harrowed with a disc harrow to make fine soil tilth. Twelve (12) plots each measuring 1.6m x 1 m were prepared for each field. One (1) metre spacing was left between beds to allow the seedling tray holder to pass.The experimental design used was a Randomized Complete Block Design (RCBD). There were four (4) blocks and three (3) treatments resulting in 12 plots. The treatments were the transplanting depths of 5cm, 7.5cm and l0cm.

Two people were involved in the testing of the device. The tray containing the seedlings was placed on the tray holder and pushed to follow the person doing the transplanting. The furrow opener was penetrated into the soil by holding the handles and applying some little amount of force. A seedling was picked from the tray and placed into the seedling delivery pipe with the furrow opener closed. The seedlings were picked with the root surrounding the growth media and made to fall freely through the delivery pipe to the furrow opener. The movable handle acted as a lever for the closing and opening of the furrow opener. By pushing the movable handle against the seedling delivery pipe, the furrow opener opened creating the transplanting pit and allowing the seedling to gently fall into the pit created. The transplanter was then lifted up with the furrow opener in such away not to cause injury to the stem and leaves on the seedling. Ten seedlings were transplanted on each plot with planting spacing of 40cm for both inter-row and intra-row spacing. The spacing between plants was indicated by the plant spacing marker which marked the soil surface to show the next point to penetrate. The depth regulator was adjusted to allow for transplanting on the required depth on each plot in a block. The depth regulator was adjusted to allow for transplanting at different depths in the different plots.

Field efficiency of the transplanter per each transplanting activity was calculated by dividing the actual field capacity by theoretical field capacity and multiplying by 100%. The actual field capacity for each transplanting activity was calculated by dividing the area covered per plot by the time taken in transplanting. The theoretical field capacity, however, was determined for each transplanting activity using the formula:

Theoretical field capacity (TFC) = (v x w)/ 10.

Where, v is the speed of travel (Km/h) and w is the working width of the transplanter (m) . Seedlings transplanted on each plot were monitored for 20 days to check seedling survival and seedling moriality. Data on this were used to calculate for plant percentage mortality.

$$\%\text{Plant mortality} = \frac{\text{Number of seedlings dead}}{\text{Number of seedlings survived}} x\ 100\%$$

Data analysis. The data collected were analysed using Analysis of Variance (ANOVA) at a significance level of 5% using GenStat Twelfth (l2th) Edition. The Tukey HSD test was used for mean comparison. Means were determined and graphs plotted using Microsoft Excel.

Results and discussion

The handheld vegetable transplanter was successfully constructed using locally available materials. The main components of the constructed transplanter consisted of two handles, a seedling guide pipe, furrow opener, depth regulator and plant spacing marker. The constructed transplanter was able to transplant successfully at the three different transplanting depths by adjusting the depth regulator.

Effective plant spacing was achieved by adjusting the plant spacing marker. The tip of the furrow opener was sharp enough to penetrate the soil to the desired depth. The constructed transplanter was simple and easy to operate. The seedling tray holder consisted of table top, legs, and wheels. The seedling tray holder made transplanting easier and comfortable by addressing the issue of having to bend down to pick seedlings up into the seedling guide pipe.

The result of the field test indicated that the deeper the seedlings were transplanted, the wore time was needed in carrying out the operation. Thus, the highest time of transplanting was recorded with 10 cm, followed by 7.5 cm and 5cm in that order. Comparing the developed transplanter to manual transplanting using cutlasses and hoes, it was found that the time for carrying out the operation manually was about two times or more than when carrying the same work with the developed transplanter. The ANOVA results also showed significant differences ($p<0.05$) among the treatments for the time of using the transplanter while that of the manual method showed no significant differences.

Figure 2 shows the mean field efficiency of the handheld vegetable transplanter at the three different transplanting depths of 5 cm, 7.5 cm and 10 cm. Transplanting at 5 cm depth had the highest field efficiency (91.05%), followed by 7.5 cm depth (74.44%) and the 10 cm depth recording the least field efficiency of 5 1.22%. The data generally show a more efficient tool especially when operated at 5 cm and 7.5 cm depths. The field efficiencies obtained was found to be more than that reported by Hanna (2016) which varied from 55% to 67.5%. The same trend was shown for the field capacities with 5cm planting depth having the highest value of 0.008 ha/h. The lowest value was recorded for the transplanting depth of 10 cm with an average field capacity of 0.005 ha/h.

Post-transplanting assessment showed that plants at depth 10 cm had the highest percentage mortality of 10%, followed by plants at depth 7.5 cm which had a percentage mortality of 2.5% whiles those at depth 5cm recorded no morality. Although this is in contrast to the result of Vavrina *et al*. (1994) who reported that planting pepper seedlings at deeper depths enhanced the growth and yield of the plants. This could be due to fact that the depth 10 cm is too deep for the seedlings thereby causing seedl ing moriality because almost more than half of the seedling height was buried at this depth. This means that the deeper the transplanting depth, the higher the transplanting mortality using this transplanter.

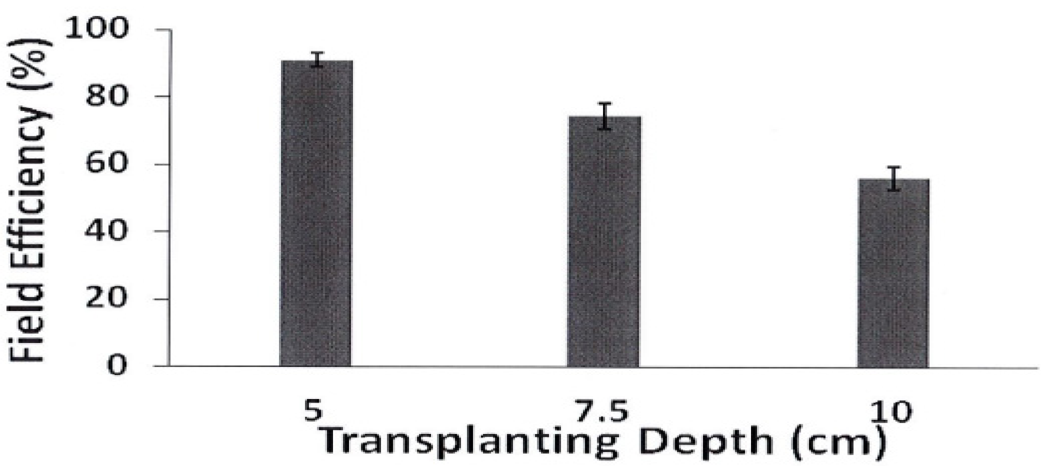

Figure 2. Field efficiency as affected by transplanting depths

Conclusion

The manually operated vegetable transplanter was developed and field tested using bell pepper as a test crop. Three transplanting depths (5, 7.5 and 10 cm) were used as treatments in the test and the 5 cm 7.5 cm planting depth produced the highest efficiency of 91.05% and 74.44%, respectively. In using this transplanter, it is recommended to use any of these two depths instead of 10 cm.

Acknowledgement

Gratis Foundation workshop staff and technicians in Cape Coast, Ghana are acknowledged for their role in the fabrication of the transplanter. This paper is a contribution to the Fifteenth RUFORUM Annual General Meeting held 2-6 December 2019 in Cape Coast Ghana.

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