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Research Application Summary

Mechanised multi-row seeding of finger millet

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Abstract

Finger millet (*Eleusine coracana* L. Gaertn) in sub-Saharan Africa is produced at subsistence level by low income earners and particularly in drought prone areas. Unfortunately, production is affected by many factors most especially weeds. The effect of weeds is made more important because finger millet is sown by broadcasting. Row sowing of finger millet has been shown to significantly reduce finger millet weeding labour requirements to economic levels. Despite the great benefits associated with finger millet row sowing, the practice is still burdensome because it is a tedious and time wasting process. It is mostly done manually or with innefficient single-row seeding equipments. Research targeting mechanized crop production is greatly inclined to high powered equipment, not easily affordable by low income communities and mostly suited for large grains. Mechanised seeders currently availabale are used for large seeded crops and cannot be used for finger millet as their metering mechanisms releases big quantities of seed in a furrow, necessitating another tedeoud exercise of thinning. In order to solve the finger millet sowing associated drudgery, there is need to review the existing seeding mechanization efforts in order to come up with a design appropriate for tiny seeds that is multi-row, user friendly to low income communities, time saving and able to perform in the sandy soils of most finger millet growing parts of Uganda and elsewhere.

Key words: *Eleusine coracana*, mechanized seeder, multirow seeder, Uganda, weeding

Ré**sum**é

Le millet de doigt (*Eleusine coracana* L. Gaertn) est produit en Afrique subsaharienne par les personnes à faible revenu pour la subsistance et particulièrement dans les zones sujettes à la sécheresse. Malheureusement, la production est influencée par de nombreux facteurs, surtout les mauvaises herbes. L’effet des mauvaises herbes est rendu plus important parce que le millet de doigt est semé à la volée. Il a été montré que son semis en ligne limitait les besoins en main d’œuvre de désherbage aux problèmes économiques. Malgré les grands avantages associés au semis en ligne, la pratique est encore de taille parce que le processus est fastidieux et entraine des pertes de temps. Il est principalement fait manuellement ou avec des équipements de semis inefficients. Les recherches ciblant la culture mécanisée est majoritairement tournée vers des équipements à haut puissance, pas facilement accessibles aux populations à faible revenu et surtout adaptés aux gros grains. Les semenciers mécanisés actuellement disponibles sont utilisés pour les cultures à grosse semence, et ne peuvent pas être utilisés pour le millet de doigt, car leurs mécanismes de mesure libèrent de grandes quantités de graines dans un sillon, nécessitant des travaux supplémentaires. Afin de résoudre les problèmes associés au semis du millet, il est nécessaire de revoir les efforts actuels de mécanisation des semis existants afin d'élaborer un dispositif approprié pour les petites graines, qui sera à multiple lignes, pratique pour les populations à faible revenu, et capable d'opérer dans les sols sablonneux des régions de culture de millet en Ouganda et autres régions.

Mots-clés: Eleusine coracana, semoir mécanisé, semoir multi-ligne, désherbage, Ouganda

Introduction

Finger millet (*Eleusine coracana* L. Gaertn) is endowed with proteins and minerals, and thus important in preventing malnutrition, in addition to being a major food security, nutrition and income sourcing crop, particularly in the drought prone parts of sub-Saharan Africa. Generally, production of finger millet is still at subsistence level with very low grain yield estimated at 400-800 kg/ha, although the potential is about 2500 kg (Tenywa *et al.,* 1999). A major cause of persistent low finger millet yield is the effect of weeds (Nyende *et al.,* 2000). The main cause of this effect is difficulty in weeding caused by broadcast sowing. Broadcast sowing impairs manual and mechanized weeding to the extent that the growing of crop becomes non-economical. As such, most communities opt for grain crops such as sorghum and bullrush millet, both of which may not perfectly substitute for the unique values associated with finger millet as a food security crop. A feasible option to reduce weeding drudgery would be sowing finger millet in rows. Row sowing has been shown to significantly diminish the finger millet weeding labour requirements to economic levels. Despite the great benefits associated with finger millet row sowing, the practice is still burdensome since it is majorly done manually where furrows or planting holes are opened by a plough or by a dibbling stick and the seeds are either dropped in by hand, holed tin or by bamboo stick. There exist scanty single-row seeding equipment which are either manually operated or animal drawn. These use a drill seed metering mechanism which render them tedious, inefficient and wasteful in terms of material and time. They release a large amount of seed which creates extra labour in subsequent thinning. In regions producing large grains, where high-powered tractors are developed, there is enlargement of the seeder's working width and operational speed as well as the seeding quality under high speed operation. When it comes to tiny grains such as finger millet, it can only realize the sowing in drill. But it fails to satisfy the production requirements of the planting leading to problems of great differences of planting density, high thinning intensity, as well as low seedling rate, waste of seeds and poor productivity. The development of a device of precision seeding suitable for tiny–seed crops is crucial for the mechanized production of finger millet. We present in this paper a review of existing seeding mechanization efforts in order to come up with a design of an efficient seeder which is appropriate for tiny seeds that is multi-row, suitable for low income communities, time saving and efficient in sandy soils of most finger millet growing in Uganda.

Types of seeders

There are various types of mechanical equipment that have been developed to simplify planting operation. Some of the planting equipment developed and being used are discussed below depending on their power source and operation mechanisms.

a) Tractor trailed/mounted seeding devices

i) The tractor mounted planter: The tractor mounted planter is shown in Figure 1 and was developed for sowing bold seeds like groundnut, cotton and maize in six-rows. They use shoe-type furrow openers with modular boxes clamped on the rear tool bar of the frame. Each seed box (15 kg capacity) is provided with inclined-plate (120 mm diameter)-type seed metering mechanism. They have provision for different crops which is attained by changing seed plates and transmission ratio. Row spacing of 225–450 mm can also be attained by sliding the furrow openers on the rear tool bar of the main-frame. Depth of planter is controlled by the tractor hydraulic system. Field capacity of the machine varies from 0.45 to 0.60 ha/hr with 65–75% field efficiency at about 3 km/hr.

This equipment as a six row seeder and therefore, saves time, minimizes the field soil compaction and its design row spacing range can also accommodate finger millet. These design properties work well with the requirements needed for the multi-row finger millet seeder. Unfortunately, the seeder's metering device makes it only suitable for planting large seeds like maize, cotton and ground nuts. Also being tractor mounted, this makes the equipment expensive for the rural low income farmers.

Figure1: Tractor-mounted inclined-plate planter with raised-bed forming attachment for intercrop

ii) The Negative-Pressure Precision Millet Seed-Metering Device. Figure 2 shows the negative-pressure precision millet seed-metering device. It was designed to operate on the following principles: (i) the seeds are metered by pneumatic system without getting crushed; (ii) the furrow opener makes the seed channel, guides seeds and fertilizers to fall into the furrow, and covers it by humid soil; (iii) the rolling by the press wheel may reduce large holes in the soil when it is seeding. It will lower the water evaporation and preserve soil moisture, as well as adjust the moisture so that seeds closely contact the soil for better seedling and growth; (iv) the millet seed metering achieves the required seeding rate, row spacing, plant spacing, saves a large amount of seed and increases the utilization rate of the seeds; and (v) the matched horsepower 50 Hp, operational rows five lines, row spacing of 300 mm, and the seeding depth of 10-20 mm.

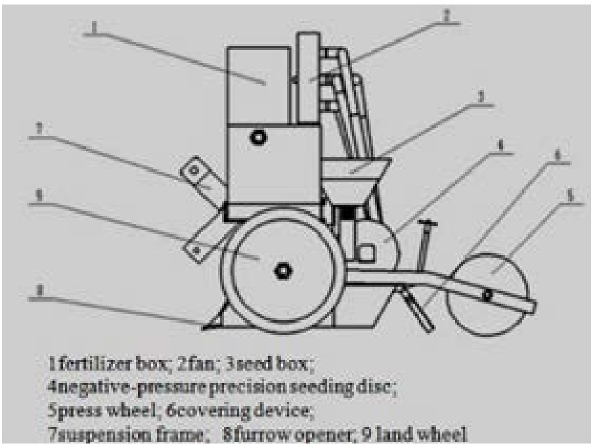

Figure 2: Schematic diagram of the millet seed-metering device (Baker *et al.,* 2002)

For this device, most of the requirements for sowing finger millet in rows would be achieved. The challenges with the devise is the requirement of a tractor and a power requirement of 50 horsepower. These renders it costly and therefore less affordable to the rural low income earners who grow finger millet. Also the equipment being metered by pneumatic system, the rural artisans' technical knowhow may not match with the required maintenance skills of the equipment.

iii) Power tiller drill machine. Figures 3 shows a power tiller mounted zero till drill machine. It is designed to consist of five inverted Tee type furrow openers, seed and fertilizer hoppers and fluted roller type metering mechanism. A compaction roller is provided for closing the slit created by furrow openers after the placement of seed. It can directly drill seed and fertilizer without seedbed preparation. It is suitable for wheat, barley, lentil, chickpea, pea and paddy with power of 8-10 horse power.

Figure 3: Power tiller mounted-zero till drill machine

Figure 4 shows a power tiller operated till plant machine. Some of its major components are the main frame, seed and fertilizer boxes, metering mechanism, transport wheel, furrow openers, hitch system etc. It is suitable for sowing seeds of wheat, soybean, Bengal gram, sorghum and related seeds in medium and heavy soil. Its working depth is 60-120 mm and plants two rows.

The lessons learnt from the power tiller operated till plant machine is that most of its operation mechanisms like multi-row furrow openers, metering system, and furrow compaction roller are suited for the requirements for the millet seeder. However, challenges like the need to purchase the whole set of equipment required, the working depth design which is much deeper than required and two rows planted at a time for the close row to row spaced crop does not optimally save time, reduce soil compaction and warrant the cost of purchase. Also it may not be well accepted in a region where they already practice ox-ploughing and would require something attachable to what the farmers are already familiar with.

Figure 4: Power tiller operated-planting machine

b) Animal drawn seeding devices

Animal drawn seeding equipments are of categories that require low power for their operation. They are generally drawn by animals like cows, oxen, horses and others therefore they are made light.

i) Animal Drawn Planter: CIAE, Bhopal. The Animal drawn 3-row inclined plate planter is designed for planting bold and small seeds. It utilizes inclined plate type seed metering mechanism. The shoe type furrow openers ensure deeper seed placement in moist zone for sowing under dry land conditions. Power from the ground wheel is transmitted to the counter drive shaft through a set of chain and sprockets. Another set of sprockets on the counter shaft transmits the power to main drive shaft. The main drive shaft drives the individual drive shafts of modular seed boxes through sets of chain and sprockets and these shafts in turn rotate the inclined seed metering plates through a set of bevel gears. It is suitable for sowing of bold (like groundnut, maize, Kabuli gram, etc.) and very small (mustard, sorghum, etc) size seeds.

Figure 5: Animal drawn planter; CIAE, Bhopal

The equipment is animal drawn, a multi-row seeder and suited for dry land. These factors make it suitable for sowing finger millet. But the seeder's power transmission system goes through many levels of driving mechanisms starting from drive wheel to the counter shaft though chains and sprockets. Then trough a second and third set of shafts, chains and sprockets and finally through bevel gears before driving the seed metering plate making it a complicated system. Its operation and maintenance would require good technical expertise. Also the seed plate metering mechanism is suitable for broad grain seeds, when it comes to tiny seeds like finger millet, some seeds can get crushed in the process leading to waste. Therefore such equipment is likely to be less suitable for rural farmers of eastern Uganda.

ii) Bullock drawn seed cum fertilizer drill. The design of a bullock drawn seed cum fertilizer drill is shown in Figure 6. The frames are made from mild steel angle iron sections over which other components are attached. The hopper of the drill is made of mild steel sheet and has separate compartments for seed and fertilizer. Fluted rollers are used for metering the seed and fertilizer, which are driven by a chain and sprocket mechanism driven by the ground wheel. Drive wheels are fixed to the frame with stub axles. One of the wheels carries a sprocket to power the fluted roller assemblies. Furrow openers are attached to the frame with the help of shanks. The distance between the furrow openers can be adjusted according to the crop. Hitch is joined to the frame to which beam is attached for pulling the drill. Seeds along with fertilizer are placed in the hopper and seed drill is moved with a uniform speed in the field. Seed and fertilizer metering devices delivers the required quantity of seeds and fertilizer into the tubes attached to furrow openers. The bullock drawn seed cum fertilizer drill is used for sowing wheat, gram, sorghum, soybean, pigeon pea, sunflower and similar seeds in rows at uniform depth. The seed rate is controlled by the metering mechanism.

iii) Animal drawn seed cum fertilizer drill. It is a low cost line-sowing device in which the seed and fertilizer are metered by the operator. Tiphan refers to three row sowing device. The drill consists of a frame made of mild steel box iron sections. For operation, the seeds and fertilizer are fed by the operator manually in the funnels, which flow to the bottom of the furrow openers and in the boot attached to the rear of the shank, respectively. Since the drill does not have a separate hopper, seeds have to be carried separately in a bag slung on the shoulder or the back of the operator.

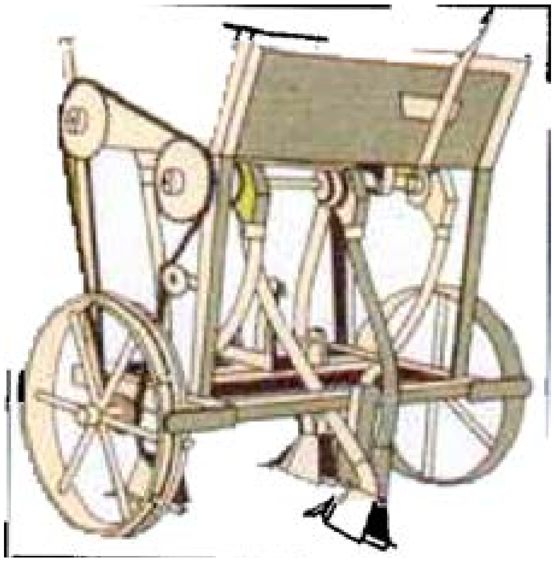

Figure 6: Animal drawn seed cum fertilize drill (CEEMAT, 1972)

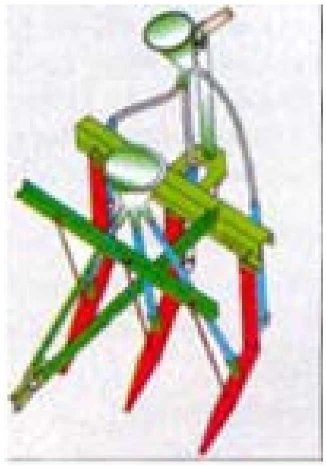

Figure 7: Animal drawn seed cum fertilizer drill (Local Name: Nimad type tiphan

The lessons learnt are that the equipment is simple, has low cost and being multi-row would suit the requirement for the rural farmers. But the lack of a seed hopper on the machine necessitates an operator to carry a bag of seeds and keep inputting the seeds in the funnel like delivery tube throughout and its metering mechanism retains the drudgery with it. These features therefore renders the equipment not well suited for small seeds like finger millet.

iv) Palabana and SA ripper-planters. The design principle of these planters is that both are single furrow attachments and can fit on any standard mouldboard plough beam. Their draft requirements are low and have easy to fit cell-wheels that meter the seed to the required seed rate. Their cell-wheel can be changed to accommodate different seed types and sizes.

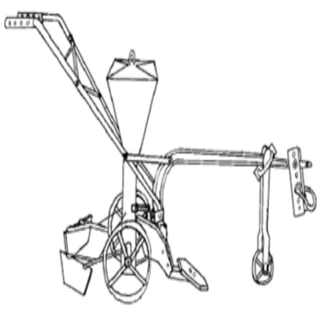

Figure 8: Palabana ripper planter (ILO, 1983)

Figure 9: SA ripper planter (Bulawayo,1983)

They open furrows, place seed and cover in one operation in both ploughed and on un-ploughed field. Both are able to work in dry land. Depth adjustment is done in the same way as in a plough; however, in this case the hitch point should be lower and the chain longer (up to about 3.5 meters) so as to ensure good penetration of the tine and efficient use of the draft power. Pulling is by 2-4 oxen or 4-6 donkeys. Weight of the attachment alone is 26.4 kg and has planting capacity of 0.15 –0.25 ha/hour for a row spacing of 900 mm. The side-plates can be adjusted to set the base of the drive (ground) wheels higher, level or lower than the base of the seed pipe. This influences the depth at which seed is placed in the furrow. The tines are double pointed to enable change over.

Most of the design principles of the prototypes in Figures 8 and 9, i.e., the furrow openers, the hitching, the draft power, the attachment principle to the common country plough frame, the drive wheel and seed metering mechanisms match well with the design principles for a multi-row seeder for the low income farmers of eastern Uganda. However, being single row seeders would not reduce drudgery, hence they are time consuming. This presents neither significant advantage over the burdensome manual row planting, nor over the traditional broadcasting sowing and over strains the working animals in pulling the seeder for a long distance during planting (Viebig, 1982; LCC, 1984; AETC, 1986), hence the need for the multi-row seeder (UPROMA, 1984, 1986).

Manual operated seeding devices. The design principle of the equipment is a mounted hand wheel hoe single row planting mechanism used for inter-culture operation on which a planting mechanism is mounted. It consists of a vertical plate with spoons, and receives drive motion from the ground wheel through chain and sprockets. For operation of the planter, a person pulls it by the rope attached to the hook while another person steers the machine by holding the handle. Varying the number of spoons on the vertical plate varies plant spacing. Plantings poons for other crops like peas, sunflower, cotton, okra, maize and soy bean are also available.

The manual seeder shown in Figure 10 can eliminate the strain a farmer experiences in trying to isolate single tiny millet seed by hand in order to be able to plant in rows and the drudgery during weeding. But on the other hand, its seed metering mechanism is suitable for broad seeds. It plants a single row, therefore it is time consuming and less efficient for the close spacing required for tiny seeds.

Figure 10: Manual Planter (Hopfen, 1969; Gite and Patra, 1981; Silsoe, 1986)

NA Veen Dibbler. The equipment is shown in Figure 11. It is an automatic dibbler, manually operated, and consists of a seed hopper, cell type roller for metering of seeds, spring actuated jaws for penetration in the soil, pipe and handle. It is used for sowing of bold seeds such as peas and also for gap filling in rows. The lessons learn are that the manual seeder shown in Figure 11 is that it can eliminate the strain a farmer experiences in trying to isolate single tiny millet seed by hand in order to be able to plant in rows and the drudgery during weeding. But it is suitable for big seeds. It also plants a single row, therefore it is time consuming and less efficient for the close spacing required for tiny seeds.

Figure 11: NA Veen Dibbler (Hopfen, 1969 ; Gite and Patra, 1981; Silsoe, 1986)

General findings

1) For category (a), tractor trailed or mounted seeders type (i) shown in Figure 1 is multi-row and efficient therefore saves time and completely eliminates the manual row planting and broadcast associated weeding and general drudgery. But the design of its seed metering mechanism is suited for big seeds. Furthermore, this type require high power which can only be generated by tractors. These are very expensive for the rural low income farmers who grow finger millet. Then for type (ii), category (a), shown in Figure 2, is the Negative-Pressure Precision Seeder. This equipment achieves the required seed rate, good row and plant spacing, reduced seed waste, can open and close the furrow. This renders the equipment suitable for as a finger millet seeder for sub-Saharan Africa farmers. However the requirement for a tractor makes it too costly. In addition, the metering pneumatic system is difficult for the rural artisan to maintain.

2) For category (b), ox-drawn seeders; the types (i) and (ii) shown in Figures; 5, 6 and 7. These are completely independent prototypes designed to be directly hitched to oxen, so when purchased, can be used independent of the existing country plough. They are affordable, but also designed to plant broad seeds, can plant one or two rows, thus their use does not completely relieve the finger millet farmers from the drudgery. Their acquisition require that farmers possess two or more completely separate units which makes it costly

and therefore not likey to serve the poor farners.

3) Type (iii) of category (b) shown in Figures 8 and 9 are some of the easily attachable to and detachable from the existing country ox-plough. These are associated with a number of challenges such as being single row seeders, not significantly able to reduce drudgery, and time consuming. They present neither significant advantage over the burdensome manual row planting nor over the traditional broadcasting sowing and over straining the working animals in pulling the seeder for a long distance during planting. Despite these limitations, their components are easily attachable to and detachable from the existing country ox-plough, so when modified into multi-row seeders and their seed metering mechanisms redesigned to suit the precision seed metering required for the tiny seeds like that of finger millet, can match the requirement for low income farmers of eastern Uganda and elsewhere in sub-Saharan Africa.

4) Category (c) manually operated devices shown in Figures 10 and 11 are seeders that can eliminate the strain a farmer experiences in trying to isolate single tiny millet seed by hand in order to be able to plant in rows. But on the other hand they are suitable for broad seeds since their seed metering mechanisms are designed for broad seed. They plant a single row, therefore are time consuming and less efficient for the close spacing required for tiny seeds.

Way forward: In order to succeed in making finger millet production viable and sustainable, it is prudent that investment should be made in designing and production of easy-to-use farmer friendly seeders. Ox-driven seeders are particularly recommended especially for eastern Uganda where light soils predominate and yet the ox is currently a traditional tool for mechanization in the region. Based on the above background, improvement of multi-row seeder should be considered since it is easy to repair by rural artisans from locally available materials. This would make them affordable. In addition, they would be easily attachable to and detachable from the popularly used ox-plough in the region. The seeder is intended to meter the seeds from the hopper through the delivery tube to the seed drop wheel which drops two to three seeds into the furrow at a time at the desired row spacing of 300 mm and plant spacing of 60 mm through a small, well sized hole on the seeder dropper wheel without crushing. The seed dropper wheel is included in the metering system to prevent the delivery tube from poring seeds into the furrow uncontrollably. This would prevent the need for the burdensome and timewasting thinning. The use of the multi-row seeding is intended to reduce on the associated drudgery, planting time and the accruing soil compaction that would be caused by single row planting of the required close spaced finger millet. The millet seeder is equipped with appropriate furrow openers to open the furrows at shallow depth and also the rolling press wheels which covers the dropped seed in the furrows and at the same time slightly compacts the soil to enable the seed get into proper contact with soil to facilitate moisture acquisition and therefore enhanced germination. The press wheel is separated by a short distance from the furrow so that there is very little time lapse between opening and closing of the furrow to interrupt evaporation. Also the pressing of the press wheel reduces on the evaporation rate and conserves moisture in the soil for the seed.

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