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A Survey on the Design, Fabrication and Utilization of Different Crops Planter

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Abstract:

Manual method of seed planting, results in low seed placement, spacing efficiencies and serious back ache for the farmer which limits the size of field that can be planted. The cost price of imported planters has gone beyond the purchasing power of most of our farmers. Peasant farmers can do much to increase food production especially grains, if drudgery can be reduced or totally removed from their planting operations. To achieve the best performance from a seed planter, the above limits are to be optimized by proper design and selection of the components required on the machine to suit the needs of crops. The problem has intensified due to the unavailability of labor in time, and multi-fold increase in labor costs. Fragmented land holdings and nucleus farm families further exacerbates the problem of availability of farm labour. So the need of a manual operated seed planter was required. In this paper we will be surveying all types of seed planters and their working operations and also proposed an advanced manual operated multi-crop seed planter.

Key words: Tillage, Planters, planter efficiency, Farm mechanization.

1. Introduction

Farm mechanization is the use of mechanical devices or systems to replace human muscle in all forms and at any level of sophistication in agricultural production, processing storage and so on in order to reduce tedium and drudgery, improve timeliness and efficiency of various farm operations, bring more land under cultivation, preserve the quality of agricultural produce, provide better rural living condition and markedly advance the economic growth of the rural sector (Anazodo, 1986;Onwualu et al., 2006).

A developing country like India is expected to continue to rely more on hand tools for the foreseeable future for cultivation. The use of hand tools for land cultivation is still predominant in India because draft animals and tractors require resources that many Indian farmers do not have easy access to. The need for agricultural mechanization in India must therefore be assessed with a deeper understanding of the small holder farmer's activities and what values farm power generated for them (Hiroyuki and Sheu, 2010).

As our population continues to increase, it is necessary that we must produce more food, but this can only be achieved through some level of mechanization. Manual method of seed planting, results in low seed placement, spacing efficiencies and serious back ache for the farmer which limits the size of field that can be planted. However, planting machine or planter that is normally required to produce more food is beyond the buying capacity of small holder farmers.

These small holder farmers still continue to plant manually, the result of which is low productivity of the crops. It is therefore necessary to develop a low cost planter that will reduce tedium and drudgery and enable small holder farmer to produce more foods and also environmental friendly.

In this paper we are surveying the design of different types of seed planters, their utilization methods advantages, disadvantages and the process involving to design and fabrication of these planters for the purpose of designing an advanced manual operated multi-crop planter.

2. Historical Background

In the past, various types of design have been developed with different design approaches which have their advantages and disadvantages and also operational limitations. Klocke (1979) described the building of two experimental planters, one using a smooth coulter and the other a ripple edged coulter. Both types of coulters were followed by hoe openers. The performance of the drills was satisfactory as long as the seed was placed into adequate soil moisture. Allen et al. (1975) used a fluted coulter in combination with a double-disk on a conservation planter. The coulter cut residue and loosened a zone of soil about 6 cm (2.36 in) wide and 7.5 cm (2.95 in) deep, Morrison (1978) developed an experimental conservation tillage planter which consisted of a rolling coulter and a double-disk opener which were combined by locating the trailing portion of a smooth rolling coulter between the disks of the double-disk opener. Adisa (1980) designed and constructed a manually operated flute planter/fertilizer distributor which was found to be 94% efficient in seed spacing but could not be used on the ridged seed bed and requires quite some effort and time to change seed drill size and seed spacing.. Kumar et, at. (1986) developed a manually operated seeding attachment for an animal drawn cultivator. The seed rate was 43.2 kg/hr while the field capacity was 0.282 ha/hr. Tests showed minimal seed damage with good performance for wheat and barley. Adisa and Braide(2012) developed template row crop planter. The planting rate of the template row planter was found to be 0.20 ha/h. Gupta and Herwanto (1992) designed and developed a direct paddy seeder to match a two- wheel tractor. The machine had a field capacity of about 0.5ha/hr at a forward speed of 0.81m/s. Also Braide and Njidda (1989) developed a combined jab planter which was found to be 73.4% efficient and was three times faster than manual planting with hoes and cutlass. Abubakar (1987) made used of the principle of jab planter in applying fertilizers. Adekoya and Buchele (1987) developed a cam activated precision punch planter which was capable of planting an untilled soil. Braide and Ahmadu (1990) developed a transplanter for some selected crops in Guinea Savannah of Nigeria which has 0.19ha/h field capacity and 20% field efficiency. All of the above designs were reported to have got quite promising results.

Bamgboye and Mofolasayo (2006) developed a manually operated two-row Okra planter. The field efficiency and field capacity were 71.75% and 0.36 ha/hr while seed rate was 0.36kg/hr with low average seed damage of 3.51%. Gupta and Herwanto (1992) designed and fabricate a direct paddy seeder to match a two-wheel tractor. The machine had a field capacity of about 0.5 ha/hr at a forward speed of 0.81mls, and there was no damage caused by the metering mechanism for soaked seeds; though 3% damage was recorded for pre-germinated seeds. Molin and D' Agostin (1996) developed a rolling planter for stony conditions, using 12 spades radially arranged with cam activated doors and a plate seed meter. Performance evaluation showed important improvement in the planting operation with reduction in human effort, more accurate stands and high field capacity. Ladeinde and Verma (1994) compared the performance of three different models of Jab planters with the traditional method of planting. In terms of field capacity and labour requirement, there was not much difference between the traditional planting method and the Jab planters.

However, backache and fatigue were substantially reduced while using the planters.

Hand-pushed and Transnational Journal of Science and Technology August 2012 edition volume2, No.728 tractor mounted row seeders (usually single and multiple row).Normally requires a well prepared seed-bed which may be ridged or flat bed.

The single and double row planters developed at the University of Southern Mindanao Agricultural Research Center (USMARC) can plant a hectare within 6-8 hours for single-row and half so much time for double-row. A disc type maize seeder developed which is simple in design and can be handily operated with ease and comfort (Rolando*et al*, 2011). It requires a pre-established furrow and after the falling of seed they are covered by soil. This is a labor intensive and time consuming process. Lara-Lopez (1996) developed a single-row direct planter for maize. The planter may be attached to a walking or riding type two-wheel tractor. Singh (1984) designed and developed a two-row tractor drawn ridge planter for winter maize. Bamgboye and Mofolasayo (2006) tested a manually operated two row okra planter developed from locally available materials. The planter had a field capacity of 0.36 ha/h with a field efficiency close to 72%.

3. Methodology

In this section we are discussed about the types of the crop planters used in the agriculture field and also discus about their performance, working and usefulness.

The basic objective of sowing operation is to put the seed and fertilizer in rows at desired depth and seed to seed spacing, cover the seeds with soil and provide proper compaction over the seed. The recommended seed to seed spacing and depth of seed placement vary from crop to crop and for different agro-climate conditions to achieve optimum yields.

But many mechanical factors, which affect seed germination and emergence, are:

a) Uniformity of depth of placement of seed.
b) Uniformity of distribution of seed along rows.
c) Transverse displacement of seed from the row.
d) Prevention of loose soil getting under the seed.
e) Uniformity of soil covers over the seed.
f) Mixing of fertilizer with seed during placement in the furrow.

Crop planting operations may involve placing seeds or tubers (such as potatoes) in the soil at a predetermined depth, random scattering or dropping of seeds on the surface (broadcasting), or setting plants in the soil (transplanting). Machines that place the seed in the soil and cover it in the same operation create definite rows. If the rows or planting beds are spaced far enough apart to permit operating ground-engaging tools or other machinery between them for inter tilling or other cultural operations, the resulting practice is called row-crop planting; otherwise, it is considered to be solid planting. Thus, grain drilled in rows 15 to 36 cm (6 to 14 in) apart is a solid planting, whereas sugar beets, with rows commonly 51 cm (20 in) apart, are grown as a row crop (Kepner et al., 1978). With appropriate planting equipment, seeds may be distributed according to any of the following methods or patterns:

a) Broadcasting (random scattering of seeds over the surface of the field);
b) Drill seeding (random dropping and covering of seeds in furrows to give definite rows);
c) Precision planting (accurate placing of single seeds at about equal intervals in rows);
d) Hill dropping (placing groups of seeds at about equal intervals in rows).

Solid planting is generally done by one of the first two methods, whereas row-crop planting may involve any of the methods except broadcasting. With the exception of broadcasters, a seed planter is required to perform all of the following mechanical functions;

a) Meter the seed;
b) Deposit the seed in an acceptable pattern;
c) Cover the seed and compact the soil around the seed to prevent rapid loss of moisture from the soil around the seed;
d) Should neither damage the seed nor affect germination, that is, the seed should be placed in the soil in such a manner that all the factors affecting germination and emergence will be as favorable as possible;
e) Since timeliness is of extrejne importance in the majority of planting operations, it is desirable that a planter be able to perform these functions accurately at fairly high rates of speed; and
f) Uniform soil penetration.

In addition to the above, a conservation tillage planter must meet the following requirements:

a) Sufficient tilling of the seed zone to obtain good seed-soil contact;
b) Ability to follow the contour;
c) Ability to roll over obstacles without machine stoppage or damage; and
d) No clogging due to residue or soil.

3.1 Types of Seed Planters

I. Template Row Planter

Template row planter was found to weigh less than 9kg, while the draft required to push the template row planter was found to be 85N. The design of this planter was made to plant the new breed of cowpea and groundnut that requires two rows on a single ridge by replacing the fertilizer metering unit with seed metering unit. Fertilizer can be applied later by replacing both seed metering units with fertilizer metering units after the emergence or germination of seeds.

Average template seed filling efficiency of the planter was found to be 88%. The cost of planter production in 2009 was fifteen thousand five hundred Naira only (N15,500). The template row planter was able to plant on both ridged and flat seed bed at average field capacity of 0.2ha/h (effective planting rate) which was quite adequate for small scale farming.

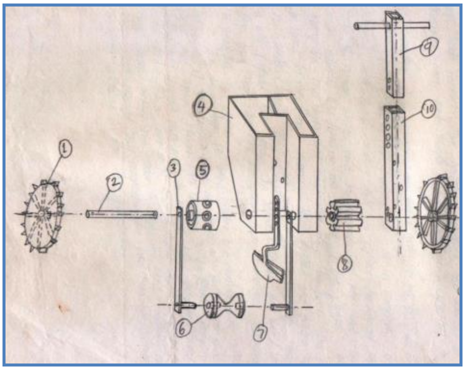

Fig. 1: Template row planter in parts.

(1) Drive wheel (2) Shaft (3) Furrow cover frame (4) Seed/ fertilizer hopper (5) Seed metering mechanism (6) Furrow cover/ presswheel (7) Furrow opener (8) Fertilizer metering mechanism (9) Male handle (10) Female handle

II. Single Row Maize Planter

The design and fabrication of a manually operated single row maize planter capable of delivering seeds precisely in a straight line with uniform depth in the furrow, and with uniform spacing between the seeds. The work demonstrates the application of engineering techniques to reduce human labour specifically in the garden, that is cheap, easily affordable, easy to maintain and less laborious to use. The planter will go a long way in making farming more attractive and increasing agricultural output. All parts of the planter were fabricated from mild steel material, except for the metering mechanism which was made from good quality wood (mahogany) and the seed funnel and tube, which were made from rubber material. The seed metering mechanism used for this work was the wooden roller type with cells on its periphery. For this design, the drive shaft directly controls the seed metering mechanism which eliminates completely attachments such as pulleys, belt systems, and gears thereby eliminating complexities which increase cost, and increasing efficiency at a highly reduced cost. The results obtained from the trial tests showed that the planter functioned properly as expected with a planting capacity of 0.0486 hectare/hr. Visual inspection of the seeds that were released from the planter's metering mechanism showed no visible signs of damage to the seeds.

Fig. 2: Photo graph of component parts of the fabricated maize planter

III. Punch Planter

A punch planter was designed and constructed for planting corn in no-till conditions. A commercial vacuum seed meter was used and positioned such that it dropped each seed individually into each punch.

The seed meter was tested in the laboratory over a greased belt and at speeds of 1.0, 2.0, and 3.0 m/s at the conditions stated by the manufacturer. Four different criteria were used for evaluating the seed distribution; multiples index, quality of feed index, miss index, and precision. The seed meter resulted in no significant changes in performance, except a small increase in the miss index.

The same seed meter was then positioned at an inclination of 22° with the vertical axis, and the vacuum level increased. These results were almost the same, except that the resulting multiples index was higher, probably due to the higher vacuum. A significant improvement in precision was observed when increasing the speed from 1.0 m/s to 2.0 m/s.

The seed meter was synchronized with the punches. No significant difference was observed in any of the criteria used for evaluating the seed spacing distribution. The reduction in the quality of feed index was between 1.6% and 4.4% for 2.0 m/s and 1.0 m/s, respectively. The precision indexes were between 17.4% and 18.7% compared to between 11.7% and 12.3% when tested with only the seed meter. The precision decreased (precision index increased) due to an interaction between the seeds and punch walls.

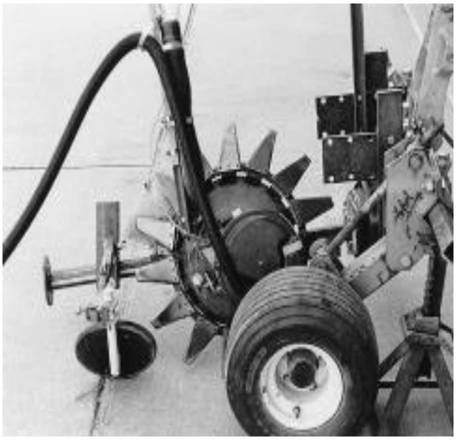

Fig. 3. Punch planter prototype set for field tests

IV. Zero tillage Multi-crop Planter

Direct drilling (seeding/planting with zero tillage technology) is one such practice that potentialy addresses the issues of labor, energy, water, soil health etc (Malik *et al.*, 2005; Gupta and

Sayre, 2007; Jat *et al.*, 2009; Ladha *et al.*, 2009; Gathala *et al.*, 2011). However, due to fragmented and small land holdings it is not affordable to purchase many machines for the sowing of different crops.

Therefore, multi-crop planters have been invented and are being used by many farmers across South Asia. The same multi-crop planter available in the region can be used for direct drilling of several crops including wheat, rice, maize, moong, bean, mustard, barley etc without any preparatory tillage and also under reduced tillage situations.

Due to fragmented and small land holdings and variable farmer typology, it is neither affordable not advisable to purchase many machines for the planting of different crops by the same farmer. The multi-crop planter can plant different crops with variable seed size, seed rate, depth, spacing etc., providing simple solution to this. In addition to adjustments for row spacing, depth, gears for power transition to seed and fertilizer metering systems, the multi-crop planters have precise seed metering system using inclined rotary plates with variable grove number and size for different seed size and spacing for various crops. This provides flexibility for use of these planters for direct drilling of different crops with precise rate and spacing using the same planter which does not exist in fluted roller metering drills. Hence, the same multi-crop planter can be used for planting different crops by simply changing the inclined plates. The planter can also be used to make the beds and simultaneously sowing the crop just by mounting the shovels and shapers which can be easily accomplished due to the given provision in the machine. The planter has the provision of drilling both seed and fertilizer in one go.

1. Frame, 2. Furrow openers, 3. Tynes, 4. Fertilizer box, 5. Seed box, 6. Chain and gear drives, 7. Drive wheel, 8. Depth control wheel, 9. Fertilizer delivery pipe, 10. Seed pipe, 11. Fertilizer rate adjusting nut, 12. Seed rate adjusting strip.

4. Proposed Methodology

In this section we are going to discuss about the proposed methodology of my current research. My proposed methodology is that design and fabricate a manually operated precision planter for different seed metering wheel. Since most of our farmers especially in the rural areas and/or small scale farmers use dibbler, matchet or sticks to sow different seeds. This dibbler, matchet or sticks is used to open the soil as the farmer drops the required numbers of seed (often times more than they require numbers are dropped) and then covers them up.

4.1 Description of the manually operated precision planter for different seed metering wheel.

The developed manually operated precision planter for different seed metering wheel consists of the adjustable handles, seed hopper, adjustable furrow opener, transport wheels, seed discharge tube, Furrow covering device, and seed metering wheel housing, adjustable row marker, chain and sprocket, idler sprocket and stand which are explain below:

a) Main Frame

The main frame is the skeletal structure of the seed planter on which all other components are mounted. The two design factors considered in the determination of the material required for the frame are the weight and strength. In this work, mild steel angle bar of 40 mm x 40 mm and 5mm thickness were used to give the required rigidity.

b) Adjustable handles

The adjustable handles consist of two mild steel flat bar each of 895 mm long fastened to the frame at two ends of the flat bar. One pipe of 20 mm external diameter attached at the end of mild steel flat bar.

c) Seed hopper

The seed hopper was made of mild steel having a frustration cross-section of a pyramid of 75mm square at the bottom, 214mm square at the top and 300mm height. The design capacity of the seep hopper is 1,750,000mm3. The capacity is based on the volume of seeds required to plant a hectare of field.

d) Seed Metering Mechanism

Metering mechanism is the heart of sowing machine and its function is to distribute seeds uniformly at the desired application rates [6]. In planters it also controls seed spacing in a row. A seed planter may be required to drop the seeds at rates varying across wide range [6]. Proper design of the metering device is an essential element for satisfactory performance of the seed planter. The seed metering device used for this work is the nylon (Fiber) seed metering wheel with cells on its periphery. The size and number of cells on the roller depends on the size of seed and desired seed rate. In this design, the seed metering wheel lifts the seeds from the hopper in the cells and drops these into the seed funnel which is conveyed to the open furrow through the seed tube. For varying the seed rate and sowing different seeds, four separate metering wheels were provided. The number of cells on the seed metering wheel may be obtained from the following expression:

$$Number\ of\ cells = \frac{\pi \times Diameter\ of\ planter's\ ground\ wheel}{Intra\ row\ spacing\ of\ seeds} \quad (1)$$

e) Adjustable type furrow opener

The design of furrow openers of seed planters varies to suit the soil conditions of particular region. Most seed planters are provided with pointed tool to form a narrow slit in the soil for seed deposition. The adjustable furrow opener permits planting at each variety's ideal ground depth. The type used for this work is the pointed bar type. These types of furrow openers are used for forming narrow slit under heavy soils for placement of seeds at medium depths. The Furrow opener is a thin mild steel (angle bar). The angle bar iron was fabricated to shoe type like structure to facilitate an easy cut through the soil. Nut and both were used to fasten the device to the frame through a hole drilled on the frame for adjusting sowing depth according to crop.

f) Adjustable Furrow Closer

The furrow closer was also designed to be adjustable. The type used for this design is the shoe type furrow closer. It was designed to allow for proper covering and compaction of the soil over the seeds in the furrows.

g) Transport wheels

Two transport wheels are made of mild steel. The front wheels have many numbers of lugs on its periphery which increase traction and reduction slip. The front wheel have small sprocket transfer the power to seed metering wheel shaft sprocket with the help of chain, in such a way seed metering wheel rotate, seed was singulated into the cell and dropped into the planting shoe/ground opener with the help of seed discharge tube that deposits the seed in the soil. The wheels are located at both ends of the frame. They are circular in shape containing periphery width 75mm which reduce side thrust and 1 inch square pipes which serves as spokes. These spokes are used to support the centre bushing or hub. The spokes are arranged in such a way that it braced the wheels circular circumference and also gives it necessary radial support. Material used for the design was a combination of both 1 inch mild steel square pipes and 3.5mm thick mild steel flat bars.

h) **Seed tube**

The seed tube is made of rubber hose pipe 30mm diameter and 300mm long. Two holes of 75mm diameter each were made at the metering housing at the lower and upper part of the metering housing. Seeds picked from the hoppers pass through the upper hole at the slide of the castellated metering mechanism to the lower hole. Into the discharge tube which deposits the seeds at desired uniform spacing into the opened furrow.

i) **Bearing Selection**

Bearings are selected based on their load carrying capacity, life expectancy and reliability. Ball bearings are fixed in the bushing provided at the two ends of the frame in other to support the eccentric shaft on which the wheels are attached. They allow the carrying of an impressive load without wear and tear and with reduced friction. This device ensures the smooth operation of the wheels. The material for the bearing is high speed steel.

j) Furrow covering device

The Furrow covering device is made of rectangular mild steel plate of dimension 80mm x120mm. It was fastened with nut and bolt to the frame through a hole drilled on the frame. The Furrow covering device is perpendicular to the direction of travel of the machine to facilitate proper covering of the soil.

k) Seed metering wheel house

The seed metering house was constructed from mild steel of 102mm internal diameter and 118mm long. Two slots of 75mm were made at the upper and lower portions on the metering housing. Seeds from the hoppers pass through the lower slot to the castellated metering mechanism to the lower hole, into the discharge tube.

l) Row marker

The function of the planter row marker is help to the operator maintain a more accurate or constant accurate row spacing. A constant crop row spacing will make for simpler and more effective cultivation especially when cultivating between row. Before planting of any type crop, consideration should be given to the subsequent cultivation operation. It was made of plated steel 33.5" long.

m) Chain and sprocket

Power transmission is done by the gear sprocket and pintel chain. When push the planter front wheel rotate then small sprocket of front wheel rotate and transfer the power to seed metering wheel shaft sprocket with the help of chain, in such a way seed metering wheel rotate, seed was singulated into the cell and dropped into the planting shoe/ground opener with the help of seed discharge tube that deposits the seed in the soil. The number of teeth in small gear sprocket and large gear sprocket was 18 and 48 respectively.

n) Idler gear sprocket

Idler sprockets should not rotate at greater speeds than are allowable for drive sprockets of the same size. They should be mounted in contact with the "slack" span of chain, whenever possible. Mount them on the outside of the chain when the arc of chain wrap on the smaller sprocket would otherwise be less than 120°. It is advisable that idler sprockets have at least three teeth in mesh with the chain. Inside mounted idlers usually account for quieter operation, especially if centers are short and speed is moderately high.

Adjustable idler sprockets are used to:

- Obtain proper chain tension when neither driving nor driven shaft is adjustable.
- Guide chain around an obstruction.
- Prevent whipping action in the slack span of chain transmitting an uneven load.
- Bring about greater chain wrap around a small sprocket, particularly if it is the lower sprocket in a vertical drive.
- Take up slack chain caused by normal chain wear.
- Provide for reversed direction of rotation of a sprocket in contact with the outside of the chain.

o) Stand

When any farmer completes the work in the field or he tired then that time stand is necessary for stand the planter for taking rest. It made by mild steel solid rod 250 mm in length and 10mm diameter.

4.2 Design Considerations

The design of manually operated precision planter for different seed metering wheel is based on the following considerations.

- The ease of fabrication of component parts.
- The safety of the operator

- The operation of the machine should be simple for small scale or rural farmers.
- The materials available locally were used in the fabrication of the components.
- Availability and cost of the materials for construction.

4.3 Determination of Planter Capacity

The capacity of the planter may be determined in terms of the area of land covered per time during planting or the number of seeds planted per time of planting. The capacity of the planter in terms of the area of land covered per time may be obtained from the following expression:

$$C_{PA} = \frac{Area\ covered\ by\ planter}{1000}\ (hectare/time) \quad (2)$$

C_{PA} = Capacity of planter in hectare/time

The capacity of the planter in terms of number of seeds planted per time may be obtained from the following expression:

$$C_{NP} = \frac{\text{Distance covered by planter per time}}{\text{Intera row spacing}} \times \text{No.of seeds per hole (seeds/time)} \quad (3)$$

C_{NP}= Capacity of planter in terms of number of seeds/time

3. Conclusions

The need of a poor and small land farmer has fulfilled by the manual operated seed planter and they can easily and effectively plants their seed in the field by these planters. But due to different crops have different requirement for the seed planting in the field. So the usefulness of the single crop planter is limited. Hence the requirement of the manually operated multi-crop planter is very high.

So we are going to design and fabricate a manual operated multi-crop planter and also evaluate its performance in the laboratory and field both.

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