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Performance Of Animal-drawn, Ripper Attached Maize-Cum-Fertilizer Planter

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በኢትዮጵያ ለአፈርና ውሃ ዕቀባ አስተራረስ ዘዴ (conservation tillage) የሚያገለግል የመዝሪያ መሳሪያ በተለይም በእንስሳት/በሰው ሃይል እየተንቀሳቀሰ የሚሰራ የመዝራያ መሳሪያ እጥረት አለ። በገበያና በምርምር ውስጥ ያሉትም ቢሆን የተወሰኑት ቀላል አፈር ላይ ብቻ ሊሰሩ የሚችሉ ሲሆን የተቀሩት ምንም እንኳን በማንኛውም የአፈር ዓይነት ላይ ሊሰሩ ቢችሉም ዘር የመመጠን ችግር ያለባቸው ናቸው። ይህን ችግር ለመቅረፍ አዲስ ድግሩ በብረት የተቀየረ ማረሻ (ሪፐር) ላይ የሚታሰር በበሬ የሚጐተት የበቆሎ ዘር መዝሪያ (Ripper attached planter, RAP) ተሰርቶ ከዚህ በፊት ከተሰራው በእርፍና ሞፈር ላይ ታስሮ ከሚሰራ መዝሪያ (sweeper attached planter, SAP) እና መሬቱን በነባሩ የአስተራረስ ዘዴ አዘጋጅቶ የሰው ሃይል (በእጅ) ዘር ከማንጠባጠብ ዘዴ ጋር (Conventional manual planting, CMP) RCBD የሙከራ ዲዛይን በመከተልና በሶስት ድግግሞሽ በመልካሳ ግብርና ምርምር ማዕከል የሙከራ ማሳ ላይ የማወዳደር ፍተሻ ተካሂዷል። የተገኘው ውጤት እንደሚያሳየው አዲሱ መዝሪያ (RAP) ዘርን በአማካይ በ28.53±4.21 ሳ.ሜ ርቀት መሬት ላይ የማስቀመጥና በአንድ ቦታ ላይ ሁለት ፍሬ ዘር የመጣል ብቃቱ 69.39±3.24% እንደሆነ ለማረጋገጥ ተችሏል። በሌላ በኩል SAP ዘርን በአማካይ በ34.37±9.11 ሳ.ሜ ርቀት ሲያስቀምጥ በአንድ ቦታ ላይ ሁለት የዘር ፍሬ የመጣል ብቃቱ 31.72±8.67 % ነው። ከጊዜ አንፃር መሬትን ከማዘጋጀትና ዘርን ከመዝራት አኳያ ሲታይ አዲሱ መሳሪያ (RAP) 14.29±2.36 ሰዓት በሄክታር ሲወስድበት፣ SAP 24.84±2.13ሰዓት በሄክታተር CMP ደግሞ 170.67±15.09 ሰዓት በሄክታር እደሚወስድባቸዉ ለማረጋገጥ ተችሏል። ዘርን ለመዝራት ብቻ የሚወስደውን ጊዜ በተመለከተ ደግሞ RAP 14.29±2.36 ሰዓት በሄክታር ሲወስድበት፣ SAP 24.84±2.13 hr.ha^{-1} እንዲሁም CMP 66.70±7.15 ሰዓት በሄክታር እደሚወስድባቸዉ ለማረጋገጥ ተችሏል። የተዘራው ዘር ብቅለትን በተመለከተ በሶስቱ ዘዴዎች መሃል ከፍተኛ ልዩነት የታየ ሲሆን በአማካይ በ RAP 43553፣ በ SAP 37347 እንዲሁም በ CMP 47117 የዘር ብቅለት ቁጥር በሄክታር ተመዝግቧል ። እነዚህ ልዩነት ያመጡ ብቃቱና ለእርሻ ስራ ያለው ምቹነት መሳሪያውን አሁን በገበያው ላይ ካሉት ለሳያርሱ ለመዝራት የእርሻ ዘዴ ከሚያገለግሉ የእርሻ መሳሪያዎች የተሻለ ያደርገዋል።

Abstract

Availability of conservation tillage implements, especially tillage-cum-planters, in Ethiopia is limited. Some of these available tillage-cum-planters perform well only on light soils while others perform poor due to the complications they have on their seed-fertilizer metering systems. To overcome the problem, a new ripper attached animal-drawn maize-cum-fertilizer planter (RAP) was developed. The implement was compared with a sweeper attached planter (SAP) and the conventional method of planting in rows (CMP) as a check in RCBD with three replication in a plot size of 10x40m^2 at Melkassa Agricultural Research Center (MARC). The results showed that the seed spacing and seed per hill uniformity (ability to drop two seeds per hill) of RAP were found to be 28.53±4.21cm and 69.39±3.24% respectively. Whereas, SAP achieved 34.37 ± 9.11cm *and 31.72±8.67% seed spacing and seed per hill uniformity respectively. Based on total time taken to prepare the land and seed sowing, RAP (14.29±2.36 hr.ha^{-1}) had shown greater efficiency over SAP (24.84±2.13 hr.ha^{-1}) and CMP (170.67±15.09hr.ha^{-1}). Based on planting operation time measured, statistically significant variation among the means of RAP (14.29±2.36 hr.ha^{-1}), SAP (24.84±2.13 hr.ha^{-1}) and CMP (66.70±7.15 hr.ha^{-1}) at 95% confidence interval was obtained. In seed emergence/plant population/ test, it was found that there was significant variation among the means of RAP (43553±2031plant.ha^{-1}), SAP (37347±4275 plant.ha^{-1}) and CMP (47117±3518 plant.ha^{-1}). This excelled performance of it and its easieness in manuverability make the new planter a better candidate for CA practice.*

Introduction

Conservation tillage (CT) means growing crops with as little disturbance to the soil as possible. The system of agriculture conserves soil and water, maintains soil fertility, reduces soil disturbance, improves water infiltration, builds up soil organic matter and supports soil life (Donald R. Daum, 1996).

Conservation agriculture technologies in general have been perfected and adopted for nearly all farm sizes, soil and crop types and climatic zones. During the last two decades, the technique of farming has been employed in most parts of the world (FAO, 1998).

Conservation agriculture in Ethiopia is at infant stage. The technique was introduced to the country only a few years ago. Although it is a new concept to the country, a lot of participatory researches have been conducted in different parts of the country so that farmers shall adopt the farming system. However, the availability of agricultural implements, especially tillage-cum-planter, for such important farming system is limited. The available tillage-cum-planters in the country are hand operated jab planter, manual and/or animal-drawn rotary jab planter and sweeper attached, animal-drawn seed-cum-fertilizer planter.

Hand operated jab planter is mostly used in no-tillage operation. It is also used for filling in spaces in the row missed by the main planter/seed drill. However, its performance is limited to light soils (C. John, 2003). The performance of rotary jab planter is also limited to light soils. Its work rate is appreciable but its work quality is poor when used on relatively hard soils unless additional weight is applied on it. However, placing additional weight on the machine to achieve optimum depth of sowing will induce stress on the power source due to increase in draft requirement (Thomas, 2000).

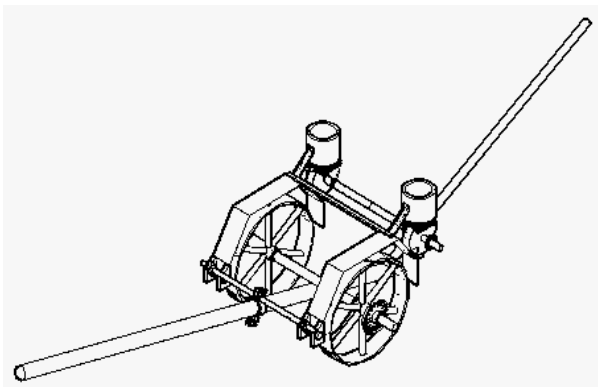
The sweeper attached planter can be used on different soils and conditions. It is a pair of oxen drawn implement which is designed to place seed and fertilizer in the furrow created by the sweeper. The problem of the machine is its seed-fertilizer metering system. The seed and fertilizer metering is done by the operator himself by swinging a lever, connected to the metering unit. This creates difficulties in achieving uniform seed spacing and seeding rate within the row. Besides, guiding the draft animals is difficult as the operator must use both of his hands simultaneously for agitating/swinging the metering unit and for exerting a force on the handle of the implement to manipulate the depth of sowing (AIRIC, 1998).

It was these limitations of the available planters that led to the conclusion that a better planter should be developed in order farmers to adopt CA in Ethiopia.

Materials and Methods

Description of the planter

The machine developed was animal-drawn, maize-cum-fertilizer planter that can be attached to a ripper* so that it can be utilized in conservation agriculture practice. The planter has two ground engaging wheels with diameter of 48 cm where one of them produces the necessary force to drive the seed and fertilizer plates through chain-sprocket drive. The total weight of the planter including seed and fertilizer filled in the hoppers is 27 kg. The hoppers of the seed and fertilizer were designed to contain 3.5 kg and 3.55 kg, respectively, and they have cylindrical shapes to facilitate easy and continuous flow of seeds and fertizer to the metering plates. The metering plates have equal diameters but with different cell size and number. The seed plate has two cells/pockets on its periphery and each of its cell was designed to hold two seeds. Whereas, the fertilizer plate has eight cells and each cell contains 0.49 gm DAP fertilizer. Both the wheels and the metering plates were designed to give 25 cm seed spacing and 100kg/ha fertilizer rate. One of the unique feature of the planter is the presence of two flexible arms which connect the planter with the beam of the tillage implement. The presence of theses arms helps the operator not to feel the load of the planter when he lowers or moves up the arm of the tillage implement to shade off soil from the ripper, in depth manipulation and in making turns at headlands as he doesn't have to carry the planter to do those activities. Thus, all the operator has to do during operation is controlling the animals along the desired direction without even trying to cover the seeds with soil as there is a chain attached to the rear parts of the planter to do the soil covering (Figures 1 and 2).



**Ripper is a modified local plow, called "Maresha" in Amharic, which its wooden wings, "digger", are replaced with a pair of rods with rings to be able to manupulate depth of plow.*

Figure 1. Isometeric view of the developed planter
(Source: Own design)

Figure 2. the developed planter in operation
(Source: Own design)

Study site

Melkassa Agricultural Research Center /MARC/ was the place at which the field performance evaluation was carried out. Melkassa is located 115 km from Addis Ababa in the Central Valley of Ethiopia. The place is situated at an altitude of 1466 m above sea level and lies on the geographical coordinates of 8° 24' 0" N, 39° 20' 0" E Latitude and Longitude respectively. It receives 763 mm mean annual rainfall, of which 70% falls during the major cropping season: June to September. The dominant soil type in the area is sandy loam. Because of its agro-climatic condition, most varieties of maize crop grow well in the area.

Field evaluation

The field trial was conducted on 30 x 120 m^2 rectangular ground, which divided into three equal sized blocks. The ground was never tilled for about a year and the previous seed grown/sown/ was teff. Except clearing out a few significantly grown weeds, the ground was never touched prior to testing. The cone-penetration index of the field were 0.3±0.09KN and 0.62±0.4KN at 0-10cm and 10-20cm soil depths respectively. The seed used for the test was "Melkassa 2" variety which had 96% germination rate and 7.66mm geometric diameter. Its 1000 seed weight was 274.55gm.

During filed trials, the developed planter was tested along with the sweeper attached planter and the conventional tillage practice with manual row planting. The test plot size was 10 x 40 m^2 and it was replicated three times following RCBD (Randomized Complete Block Design) experimental design. The number of labour force involved for each treatment was two and the average speed of operation was 0.92m/s.

Table 1 . The treatments compared

Treatment	Tillage implement	Tillage frequency	Planting	
			Seed sowing	Seed covering
Conventional method (CMP)	Maresha with "diggir"	three times	manually, row planting	manually
Sweeper attached planter (SAP)	sweeper	once, along the row	the machine itself	manually
Ripper attached planter (RAP) /the developed one/	Ripper	once, along the row	the machine itself	the machine itself

The parameters for comparison of the treatments were soil physical characteristics change, seeding pattern, field capacity and plant population density. Draft requirement of the new planter was also determined.

Soil test

Soil data at three spots of a plot (along the diagonal) to a depth of 20cm; 0-10 cm and 10-20cm, were taken to see the effect of the tillage implements of the treatments. Soil moisture content (w), soil bulk density (γ_d), porosity (n) and degree of saturation (S_r) were the parameters measured and computed.

Seeding pattern

The seed spacing, the number seeds per hill and the uniformity of seeds per hill were measured from the middle two rows of each plot which were left uncovered for a while until the measurement was done. From each row, consecuetive seed spacings/hills within 6m length were measured. Seeding depth, width and depth of cuts achieved were also measured from five equally spaced spots of a plot along the diagonal. During seed spacing measurnment, miss/skip/was assumed/considered whenever the spacing between two hills was greater than 1.5 times the theoretical spacing, i.e.25 cm (Katchman and Smith, 1995).

Time/Field capacity

Time to complete the tillage, planting and the total operations were recorded for each treatment. The average turning time at headlands were also measured. Based on the data obtained, the field capacities and efficiencies of the treatments were calculated.

During operation, there was no downtime caused by refilling the hoppers and repair and maintenance works as the implements were made ready before taken to field and the amount of fertilizer and seeds in each planter were enough to cover the plots. There wasn't also any obstruction on the field.

Plant population density

Plant population, or rather seed emergence, count was measured from the middle four rows of each plot at the twenty first day of planting. When the count was made, two or more seeds emerged at a spot were considered as one because tinning work shall be performed eventually in order to avoid competitions among the germinated seeds.

Draft requirement test

The draft requirement test was conducted for the new planter only and it comprises two evaluations; track and field tests. On track test, the evaluation was done on the planter (with out coupling it with the tillage implement). Whereas, during the field evaluation, the planter was coupled with the tillage implement. In both cases, the angle of pull was 17.45^{o} from the horizontal. The average moisture content of the field was 22% and a portable dynamometer was used for the draft mesurenment.

Data analysis

All the data collected during the evaluations were analyzed using Statistix 8 software. Statistix 8 is a commercial software package developed by the United States Department of Agriculture (USDA). During the analysis, the confidence interval level used was 95% and the two observations done in seed spacing and seed per hill measurnement were combined and analysed together. In field capacity analysis, the raw data had to be transformed to logx form so as to reduce the non-additive effect as recommended by the software.

Result and Discussion

Soil test

Regarding soil physical properies change which may caused by the tillage component of the implement, , no significant variations at two depths of the soil (0-10cm and 10-20cm) were observed (Table 2).

Table 2. soil physical property test result

Soil Depth (cm)	Treatment	Mean±SDv.			
		γ_d (gm/cm^3)	**w (%)**	**n (%)**	**S_r (%)**
0-10	CMP	1.31±0.06a	14.80±3.00a	50.47±2.21a	36.93±8.70a
	SAP	1.29±0.11a	15.48±1.76a	51.52±4.14a	39.73±4.36a
	RAP	1.28±0.09a	16.05±2.70a	51.62±3.23a	40.402±5.93a
	C.V	6.69	17.2	6.53	17.17
10-20	CMP	1.26±0.06a	17.81±2.62a	52.33±2.61a	41.12±10.76a
	SAP	1.24±0.10a	18.81±3.60a	53.33±3.84a	43.94±7.28a
	RAP	1.23±0.08a	19.07±3.68a	53.56±2.96a	44.40±9.00a
	C.V	5.21	18.79	4.90	21.24

It is obvious that, in most cases, first year trial doesn't have that much significant effect. Enfors E. *et al*. (2010) were also found no significant differences in soil physical properties between conventional tillage and strip tillage practice over four years of trials in Tanzania.

Seeding pattern

Seed spacing and number of seeds dropped per hill

In seed spacing, it was found that the SAP had a significant variation over the RAP and CMP (Table 3). This was due to the nature of the design of the planter as the operator himself was the one that had to meter/guess the spacing during operation using the rod to agitate /reciprocate/ the metering plate of the planter. The average seed spacing of this planter could have been more than the obtained results (34.37 ± 9.11 cm) if there weren't additional labor that monitor/guide the direction of seed sawing as the operator himself could have been forced to meter the seeds and guide the animals in the required direction at the same time.

Table 3. field test result of seed spacing and seed per hill of the treatments

Treeatment	Mean±SDv.	
	Seed spacing, cm	***Seeds per hill, no.***
SAP	34.37±9.11a	2.32±0.89a
RAP	28.53±4.21b	1.97±0.57b
CMP	25.00±0.00b	2.00±0.00b
C.V	26.16	29.09

Significant variations between SAP and RAP were also observed in number of seeds dropped per hill (Table 3). The field efficiency of the new planter (RAP) to drop two seeds per hill was found to be 69.39±3.24% which is much greater than that of SAP, 31.72±8.67% (Table 4).

Table 4. seed drop uniformity test result of the treatments

Seed drop uniformity	* Percent per 6 meter length		
	SAP	RAP	CMP
Missed/skiped spots	25.65±4.83	5.45±1.64	-
Single seeds	14.36±3.43	16.92±4.36	-
Double seeds	31.72±8.67	69.39±3.24	100
Multiple seed	28.28±4.87	8.24±5.88	-

* mean ± SD, n = 6

The less uniformity of SAP was caused by the vibration of the seeds in the hopper when they were drawn-out/metered by agitation even though the metering plate was designed to have a hole that should pass two seeds at a time. The lesser uniformity of the RAP comparing to CMP might be due to the vibration caused by the condition of field and/or it could be the variation of the speed of the metering plate caused by variation in walking speed of the animals. Various research reports showed that variations in seed size, planting speed, seed tube arrangement, level of seed in hopper and condition of the ground were the major causes of seed spacing and seed placement errors. Staggenborg et al. (2004) determined that variation in corn planting speed adversely affected plant spacing uniformity performance in northeast Kansas.

Seeding depth, width of cut and depth of cut

In width of cut, no significant variations among the means of the SAP and RAP were obtained. But, there was significant difference among the mean width of cut measured in the CMP and the mean values measured in the rest of the treatments.

This was due to the nature of design of the plow used in the conventional method. The plow had two flat wooden wings (the "diggirs" in Amharic) which widen the width of cut. In the rest of two treatments, these wings were replaced by two stainless steel rods which had no effect in width of cut. The presence of diggirs in the plow system actually is not recommended by most conservation agriculture experts as it causes more soil to be exposed to sunlight and erosion. Regarding depth of cut, no significance difference was found among the means of the treatments. This because the tillage equipments /plows/ used are more or less similar. Similar result was also obtained when seeding depth data of the treatments were analyzed (Table 5).

Table 5. Field test results of width of cut, depth of cut and seeding depth of the treatments

Treatment	*Width of cut (cm)*	*Depth of cut (cm)*	*Seeding depth (cm)*
CMP	29.27±2.08a	13.80±1.31a	9.23±1.33a
RAP	11.90±0.95b	15.33±1.53a	10.86±1.16a
SAP	12.86±1.27b	14.67±1.81a	10.27±1.10a
CV	10.06	5.87	7.70

Time/Field capacity

As shown in Table 6, the significant variation obtained in tillage operation time between the means of conventional method and the rest two treatments is due to the higher frequency /three times/ of tillage operations that had to be done in conventional method of land preparation.

The significant variation observed in planting operation time (seed sowing and covering) among the means of the treatments is due to the absence of seed covering mechanism in SAP, and the furrow making and manual planting operations which had to be done in CMP.

The idea of conservation agriculture practice becomes much more appealing if it is presented in total operation time. As shown in the Table, the variation among the means of the treatments in this regard becomes much more significant. This shows, the new planter could be a better candidate for CA practice.

Regarding the time lost due to turning at headlands, significant variation were observed between the means of the conventional method and the rest of the two treatments. This due to the numerious turnings that have to be done in conventional tillage practice in order to cover the whole land to prepare fine seed bed. However, the method of turning at headlands is different for RAP. Here, the operator has to hold the arm of the ripper firmly against a spot and makes the animals turn sharply. However, in the other two treatments, the operator has to carry the implements and do the turning. This actually causes fatigue on the operator especially if the implement has much weight.

Table 6. Time/Field capacity test result of the treatments

Description	Treatment	Actual field capacity,Hr.Ha^{-1}	Time lost, hr.ha^{-1}	Field efficiency (%)
		Mean±SDv	*Mean±SDv*	*Mean±SDv*
*Tillage	CMP	103.97±9.62a	-	-
	SAP	14.29±2.38b	-	-
	RAP	14.29±2.38b	-	-
C.V.		11.99		
Planting	CMP	66.70±7.15a	-	-
	SAP	24.84±2.38b	-	-
	RAP	14.29±2.38c	-	-
C.V.		11.95	-	-
*Total operation	CMP	170.67±15.09a	50.67±4.17a	70.69±0.63c
	SAP	24.84±2.13b	2.58±0.01b	89.54±0.91a
	RAP	14.29±2.38c	2.27±0.44b	84.07±1.44b
C.V.		11.90	13.11	1.53

*Note that: the raw data had to be transformed to logx form so as to reduce the non-additive effect as recommended by the software.

Plant population

The plant population obtained under SAP was less than the plant populations obtained by employing the other two treatments (Table 7). RAP had also provided less plant population than CMP did. This was due to the skip/miss of the planter from dropping seeds on the ground during operation. Even the plant population obtained under manual planting was much less than the theoretical plant population (53200 No.Ha^{-1}) which was calculated with assumptions of single plant per spot, 100% seeds germination rate, 25cm intra-row and 75 inter-row seed spacings. This might be due to the lesser precipitation amount obtained during the trial period.

Table 7. Field test result of the treatments on plant population

Treatment	Mean±SDv., No.ha^{-1}	C.V
CMP	47117±3518a	7.46
RAP	43553±2031a	4.66
SAP	37347±4275b	11.45

Draft requirement

The field draft requirement of the implement in general found to be 863.02 ± 11.20N which is less than the draft output of a pair of local breed oxen (890N). The draft requirement is not large enough to iduce stress on the pulling animals. This was the result of the presence of wheels and their designed width dimension (10 cm) which helped the planter to rotate over the surface of a ground without significant sinkage.

Table 8. Horizontal draft requirement of the planter

Description	Track test	Field test
No. of observation	10	10
Mean±SDv, *N*	36.79±1.78	863.02±11.20
Minimum draft requirement, *N*	33.22	844.19
Maximum draft requirement, *N*	38.93	874.47

Generally, the new planter (RAP) was developed after careful observations of the merits and limitations of the available planters for CA practice. As it had been shown, the performance of the planter excelled the sweeper attached planter. Its performances in seed metering and uniformity of applications were found to be closer to the seed spacings and uniformity which can be achieved by employing manual planting. It also saved much time in performing planting operation when it was compared with the sweeper attached planter and the conventional method of seed sowing in rows. Its seed damage (< 3%) and draft requirement were also found to be insignificant. These and its adaptability to different soil types/conditions make it a much better candidate for CA practice implementation.

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