Applied Research and Innovation (ARI)

ISSN: 2993-8988 (ONLINE)

VOLUME 4 ISSUE 1 (2026)

PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

Applied Research and Innovation (ARI)

Volume 4 Issue 1, Year 2026
ISSN: 2993-8988 (Online)
DOI: https://doi.org/10.54536/ari.v4i1.6334
https://journals.e-palli.com/home/index.php/ari

On Farm Evaluation and Verification of Mini Tractor Drawn Potato Planter

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Article Information

Received: November 25, 2025
Accepted: February 07, 2026
Published: April 10, 2026

Keywords

Field capacity, Field efficiency, Hopper filling, Potato Planter, Speed

ABSTRACT

Potatoes are a key staple food in Ethiopia. This crop provides good potential for farmers to increase their revenue. This also increases productivity and gives enough opportunities for value addition. However, manual planting requires more time and labor. To address this issue, a tractor-drawn automatic row planter was designed. The prototype tiny tractor-drawn potato planter comprises a hopper, a cup seed-metering mechanism, a furrow opener, a ground wheel, and a furrow-covering device. The potato planter's performance was tested in the laboratory, and field experiments were carried out to investigate the influence of planter forward speed and hopper filling level on several dependent metrics such as missing index, multiple index, precision index, and feed quality index. Additionally, the study found that mean seed spacing, multiple index, missing index, precision index, and quality of the feed index were all greatly impacted by operating speed. As forward velocities increased, the mean seed spacing value varied from 26.85 to 30.57 cm. The ranges of the multiple indexes and miss index were 9.65% to 16.70% and 10.75% to 22.70%, respectively. Greater cup velocity, which allows the seeds less time to fill the cups, can be the cause of a greater missing index value at higher speeds. The precision index value fell between 12.63 and 17.46%, while the quality of feed index ranged from 66.25 to 76%. At a forward speed of 1.5 km/h, the machine's mean effective field capacity and field efficiency were 0.151 ha/hr and 84.09%, respectively. It was revealed that the average depth of seed planting was 6.94 cm. Based on the performance evaluation results, it is concluded that the tractor drawn automatic potato planter is satisfactory and can be subjected to further modifications at the seed metering mechanism so as to increase field capacity and reduce operating cost of the machine by increasing the no. of rows and fertilizer application system should be incorporated.

INTRODUCTION

Agriculture contributes significantly in Ethiopian economy. Ethiopia's economic development hinges on a sustainable agricultural sector, which supports its growing population. The adoption of farm equipment is critical for increasing productivity, minimizing labor, and ensuring the timely and efficient use of resources. In addition to staple crops such as cereals and pulses, vegetable cultivation is a key component of a robust, diversified food security strategy.

Potatoes represent a major cash crop with high nutritional value and considerable adaptability to various soil types and climatic conditions. Ranked as the fourth most significant global staple food (Kibar, 2012), the potato is also a resilient species in the face of climate change. Its high water-use efficiency, yielding more nutritional value per liter than other primary staples, underscores its potential for cultivation throughout Africa (Vita and IPF, 2014). Consequently, Ethiopian smallholder farmers rely on potato production as a key strategy for improving monetary income and ensuring food security.

The reliance on traditional methods makes Ethiopian potato cultivation highly labor-intensive. The most demanding step is planting, which alone requires about 50% of the total labor (Singh *et al*., 1981). Performed manually, this process is inefficient, costing 54.3 man-days per hectare (Hossain *et al*., 2004). A critical seasonal labor shortage further compounds this problem, leading to delayed sowing and substantial losses in yield.

In response to the difficulties confronting potato producers, a two-row potato planter, operated by a mini-tractor, was developed by the AAERC. The introduction of such mechanical planters necessitates performance testing under real-world farming conditions. Consequently, this study was initiated to evaluate the field performance of the AAERC-model tractor-operated, two-row potato planter on farmers' fields.

MATERIALS AND METHODS

Description of AAERC potato planter

The AAERC potato planter is a two-row, automatic implement designed for use with a mini-tractor. Its main components include a hopper, base frame, potato metering device, seed tubes, furrow openers, soil-covering ridger, drive wheel, and chain-and-sprocket power-transmission system. Mounted on a tractor's three-point linkage and powered by a 25 hp diesel mini-tractor at low gear, the planter performs three functions simultaneously: opening furrows, sowing seeds, and forming ridges. Power is transmitted from the drive wheel to the top transmission shaft via the chain and sprocket. The machine is designed to be easy to operate and maintain. The planter is shown in Fig. 1.

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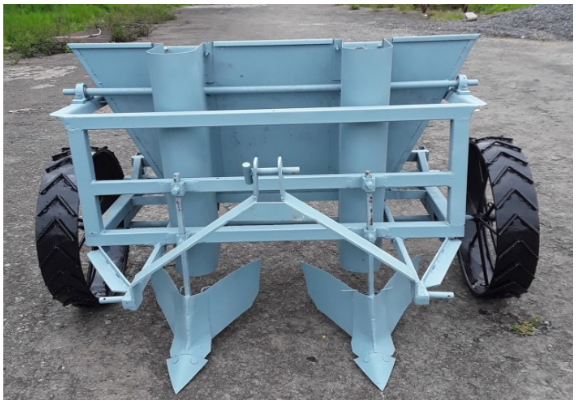

Figure 1: A mini tractor operated two row potato row planter

Working principle

The seed metering mechanism of the potato planter is a vertically-driven cup-type system. The planter is attached to the tractor via its three-point linkage using a pin. As the tractor moves forward, power is transmitted through a chain-sprocket arrangement to rotate the metering device located beneath the seed hopper. Cups mounted on the chain at uniform intervals pick up individual seeds as they move upward through the hopper. When the chain carries the cups to the top of their path, they invert over a chute, dropping the seeds precisely into the furrow that has been opened by the furrow opener at the front of the machine. Immediately after seed placement, two consecutive ridgers cover the seeds with soil and form a ridge, completing the planting process in a single, integrated operation.

Performance Evaluation of Potato Planter

A performance evaluation of the potato planter was undertaken, focusing on critical operational criteria such as seed rate, mechanical damage, seed distribution, seed placement, power requirement, field efficiency, and fuel consumption. The methodology for this evaluation involved a combination of laboratory and field-based tests.

Mechanical seed damage test

To determine the percentage of seed damage that occurs during actual operation, a mechanical damage test was carried out. The damaged seeds were weighed separately from the metered seeds, and the percentage damage was computed as follows:

Seed Distribution Test

$$\text{Damage percentage} = \frac{\text{Weight of damaged seed}}{\text{Total weight of seeds collected}} X100$$

The purpose of this test was to investigate seed metering differences from furrow to furrow. The quantity of seeds released after 20 ground wheel revolutions is counted during the calibration test. Each furrow opener's total number of seeds was tallied. Three replications of the test were conducted.

Performance evaluation of the planter

Performance indices for the planter were generated by comparing the measured inter-seed distance to the theoretical spacing. These indices included the multiple indexes, miss index, and quality of feed index, precision, mean, and standard deviation (Al-Gaadi, 2011).

Mean seed spacing

Mean seed spacing (S) is the mean of total number of spacing measured.

Where, N = total number of spacing measured

Xi = distance between consecutive seeds

$$S = \sum_{i=1}^{N} \frac{X_i}{N}^{-}$$

Uniformity of seed spacing

To quantify the regularity of plant spacing, the number of plants per hill and the inter-seed distance were measured, following the established methodology of Parish *et al.* (1991). The subsequent analysis involved calculating the standard deviation and coefficient of variation with the following equations:

Where, SD = Standard deviation

CV = Coefficient of variation

$$SD = \sqrt{\frac{(Xi - X)^2}{n}}$$

$$CV = \frac{SD}{X}$$

n = Total number of seeding actions, Xi = ith spacing X = Mean spacing.

Miss index

The miss index indicates the frequency of seeds deviating from the target spacing. It is calculated as the percentage of spacing intervals between successive seeds that exceed 1.5 times the theoretical spacing. To determine this, the distances between seeds were measured over a 50-meter span during field operation.

Where, n_1 = Number of spacing in the region > 1.5 theoretical seed spacing

$$I_{Miss} = \frac{n_1}{N} X100$$

N = Total number of observations

Multiple indexes

The multiple indexes are an indicator of more than one seed dropped within a desired spacing. It is the percentage of spacing that are less than or equal to half of the theoretical spacing in mm.

Where, n_2 = Number of spacing in the region ≤ 0.5 theoretical seed spacing

$$I_{Mult} = \frac{n_2}{N} X 100$$

N = Total number of observations

Quality of feed index

The frequency with which seed spacing approaches the theoretical aim is measured by the Quality of Feed Index (QFI). It is computed as the proportion of spacing that are between 0.5 and 1.5 times the theoretical spacing. The following is the mathematical expression for this index:

$$I_{qfi} = 100 - (I_{Miss} + I_{Mult})$$

Where, I_{miss} = Miss index and I_{mult} = Multiple index

Precision index

The precision in spacing (Ip) is defined as the coefficient of variation of the seed spacing, representing the inherent variability after excluding the effects of multiple seeds and missed spacing.

$$I_p = \frac{S_d}{S} X 100$$

Where, S = Theoretical seed spacing

Sd = Standard deviation of the spacing more than half but not more than 1.5 times the set spacing S

Field performance test of the planter

The field test was conducted in a farmer's field to evaluate the performance of a 25-hp mini tractor paired with a native ardu plough. The plough was used to prepare a fine seedbed for potatoes. Following the RNAM test codes (1995), all tractor-implement performance parameters were measured and recorded by a team consisting of the tractor operator and three data collectors.

Seed spacing

During the field trial the seed to seed spacing was measured in the field at five different locations randomly with measuring tape.

Row to row spacing

While conducting the field test of the planter the spacing between two adjacent rows was measured at five randomly selected locations with the measuring steel tape and average was determined to represent row to row spacing.

Height and width of ridge

At three randomly selected locations in each plot, a meter scale was used to measure ridge height and width.

Wheel slippage

The wheel slippage was determined by marking a reference point on the tractor's drive wheel and measuring the forward distance traveled for ten revolutions under both no-load and loaded conditions on the same surface. The percentage of slippage was calculated as follows:

$$\text{Wheel Slippage} = \frac{M_2 - M_1}{M_2} X 100$$

Where, M_2 = Distance covered at 10 revolutions of the tractor drive wheel at no load (m)

M_1 = Distance covered at 10 revolution of tractor drive wheel with load (m).

Theoretical field capacity

The tractor's travel speed and operating width were taken into account while calculating the theoretical field capacity. The following formula was used to calculate the theoretical field capacity, which was given in ha/hr:

$$\text{Theoretical field capacity (ha / h)} = \frac{W \times S}{10}$$

Where, W = Width of planter, m and S = Speed of operation, Km/h

Effective field capacity

The effective field capacity (ha/hr) was determined by measuring the total area covered, including all non-productive time for turning at row ends and refilling the seed hopper.

$$\text{Effective field capacity (ha / h)} = \frac{\text{Area of Plot (ha)}}{\text{Time taken (h)}}$$

Field efficiency

Field efficiency is the ratio of the effective field capacity to the theoretical field capacity as follows:-

$$\text{Field efficiency} = \frac{\text{Effective field capacity}}{\text{Theoretical field capacity}} \times 100$$

Fuel consumption

The refill method was used to calculate the fuel consumption. Before the planting operation began, the tractor's gasoline tank was completely filled. A measuring cylinder was used to top off the gasoline tank after the planting process was finished. The amount of fuel utilized during a specific time period was taken into consideration.

Germination count

The germination rate was evaluated one week post-planting. This was done by counting the emerged seedlings in a 5-meter sample row and calculating the percentage of seeds that had germinated.

Operation cost estimation

The operational cost of the potato planter was determined in both Birr per hectare and Birr per hour, based on fixed and variable costs. Depreciation was calculated using the straight-line method, which assumes an equal annual reduction in the machine's value. The total annual cost was calculated as follows (Hunt, 1995).

Where, AC = annual cost of operating the planter, Br/year

$$AC = \frac{FC(\%)*P}{100} + \frac{A}{C}.[R\&M)*P + L + O + F + T]$$

FC% = annual fixed cost percentage

P = purchase price of the potato planter, Br, A = annual planted area, ha

C = Effective field capacity of the planter, ha/hr

R&M = repair and maintenance cost decimal of purchase price, Br/hr

L= labour cost, Br/hr, O = oil costs, Br/hr, F = fuel costs, Br/hr

T = cost of tractor used by the potato planter, Br/hr (for self-propelled machine it is zero)

Experimental design and statistical analysis

Experimental treatments were set up in Randomized Complete Block Design (RCBD) with three replications. The data obtained were statistically analyzed by R statistical software. The analysis of variance (ANOVA) and mean table for different parameters were tabulated and the level of significance was reported.

RESULTS AND DISCUSSION

A two-row automatic potato planter, operated by a mini tractor, was subjected to both laboratory and field assessment. The subsequent data analysis and a discussion of the findings are presented in this chapter.

Calibration of planter

After the ground wheel was turned 20 times, metered seeds were gathered from each of the two furrow openers. The seed rate was then computed, and the findings are shown in Table 3. According to the package of practices, a potato seed rate of 2400–2700 kg per hectare is advised. As a result, the potato planter's calibration yielded 2529 kg/ha, which is within the necessary seed rate. It was shown that as speed increased, the seed rate reduced because the cell's exposure period to seeds was shortened. Due to the cups' shorter exposure time to seeds, it was found that the seed rate reduced as speed increased. Due to the opportunity for cups to pick up a seed, the seed rate increased as the hoper filling level increased.

Mechanical seed damage

The seed were collected randomly during calibration and observed for damaged seeds from a two kg seed lot, the percentage of seed damaged were calculated. Table 3 shows how forward speed and hoper filling level affect mechanical seed damage. At speeds of 1.5 km/h, 2.0 km/h, and 2.5 km/h, the mechanical damage was found to be 0.920%, 0.933%, and 0.943%, respectively, falling within the allowable range of 1%. It is evident that in all hoper filling levels of potato seeds, mechanical seed damage increases with speed. Because the metering roller rotated at a faster pace, there was more mechanical seed damage. The cup strikes the seeds more forcefully at faster rotational speeds, causing mechanical damage.

Table 3: Seed rate and mechanical damage at different speed and hoper filling

Variables		**Seed rate (kg/ha)** (Mean)	**Mechanical damage (%) (Mean)**
Speed(km/h)	Hoper filling level		
1.5		2544	0.89
2.0	Halve (HF1)	2508	0.92
2.5		2456	0.95
1.5	Three fourth (HF2)	2549	0.90
2.0		2514	0.93
2.5	Full (HF3)	2486	0.97
1.5		2557	0.90
2.0		2520	0.95
2.5		2490	0.98

Performance evaluation of potato planter

Field testing was conducted on a 50-meter strip of plowed soil to evaluate planter performance. The planter was operated at forward speeds of 1.5, 2.0, and 2.5 km/h with hopper fill levels of 50% and 75%. These combinations were selected to achieve the target seed spacing of 25 cm. The following indices were calculated from the field observations: seed spacing, miss index, multiple index, quality of feed index, and precision index.

Seed to seed spacing

Table 4 displays the average potato seed-to-seed spacing at various operating speeds, including 1.5, 2.0, and 2.5 km/hr. Table 4 shows that the average potato seed spacing is 26.85 cm at an operating speed of 1.5 km/hr, which is near the suggested seed spacing of 25 cm. However, as operating speed increases, so does the planting uniformity or coefficient of variance of planting spacing. Because the metering system rotates more quickly at higher operating speeds, potatoes are spaced more often and irregularly. Therefore, an operational speed of 1.5 km/hr could be suggested for the planter's field operation, taking into account the recommended seed-to-seed spacing of potatoes at 25 cm.

Table 4: The effect of seed operational speed (km/hr) on seed spacing (cm)

Operational speed(km/hr)	**Seed to seed spacing (cm)**		
	Mean	**Standard deviation**	**CV (%)**
1.5	26.85	1.83	6.19
2	27.6	2.03	8.48
2.5	30.57	2.13	9.85

Effect of planter forward speed and hopper filling level on seed missing index

The planter forward speed has a significant influence ($p < 0.05$) on the seed missing index, according to the analysis of variance (ANOVA). Table 5 shows how forward speed and hopper filling level affect the seed missing index. For various combinations of forward speeds and hopper filling level, the missing index varied from 10.75% to 22.70%. The forward speed of 2.5 km/hr had the highest missing index (22.70%), while the forward of 1.5 km/hr had the lowest missing index (10.75%). From the percentage of missing seed is rising together with operational speed, suggesting that speed has a significant impact on the quantity of missing seed. This occurred because the revolving cup on the chain rotates more quickly at greater speeds, which prevents potato tubers from being placed in its cup. A 1.5 km/h operating speed can be suggested for the planter's field operation given the quantity of missed seed. (Momin, 2006) assessed a semi-automatic potato planter and found that for operating speeds of 1.8 and 2 km/h, the missing index was 10 and 13% (Gaadi & Marey, 2011) also reported that the performance of an auto feed cup-belt potato planter under different operating conditions with different tuber shapes for whole and cut tubers. The highest missing index of 16.42% at 3 km/hr travels speed.

Table 5: Effect of planter forward speed and hopper filling level on miss index (MISI)

Parameter		**Source of variation**			**LSD (5%)**
	Forward Speed level	V_1	V_2	V_3	
MI (%)		11.02[b]	12.88[b]	21.73[a]	2.13
	Hoper loading level	H_{25}	H_{50}	H_{75}	
		14.68[a]	15.48[a]	15.47[a]	3.39
		Interaction(V*H)			
	Forward speed level	H_{25}	H_{50}	H_{75}	0.88
	V_1	10.9[c]	11.4[bc]	10.75[c]	
	V_2	11.65[bc]	12.35[bc]	14.65[b]	
	V_3	21.5[a]	22.7[a]	21[a]	

Means followed by the same letter (or letters) do not have significant difference at 5% level of probability.

Effect of forward speed and hopper filling level on multiple indexes

The analysis of variance (ANOVA) table revealed that the planter forward speed, hopper filling level and the interaction between planter forward speeds with hopper filling level ($p < 0.05$) had significant effect on the multiple indexes. The effect of forward speed and hopper filling level on multiple indexes is presented in Table 6. The multiple indexes ranged from 9.65 % to 16.70 % for all levels of forward speeds and hopper filling level. The maximum multiple indexes were observed, for lowest level of forward speed and three fourth level of hopper filling. However, the lowest multiple index, 9.65% was for maximum level of forward speed (S3) and maximum level of hopper filling (HF3). The multiple index decreases as planter forward speed increases for all levels of hopper filling. According to Misener (1979), who evaluated cup- and pick-type potato planters, the average multiple index per 30.5 m of row varied with forward speed: from 6.2% to 33.6% for the cup-type planter and from 6.8% to 29.0% for the pick-type planter.

Effect of forward speed and hopper filling level on quality of feed index

The quality of feed index was significantly affected by planter forward speed and hopper filling level ($p < 0.05$).

Table 6: Effect of planter forward speed and hopper filling level on multiple indexes (MULI)

Parameter		Source of variation			Measure of differences
	Forward Speed level	V_1	V_2	V_3	LSD (5%)
MI (%)		15.24[a]	13.47[b]	10.53[c]	0.88
	Hoper loading level	H_{25}	H_{50}	H_{75}	1.52
		12.21[b]	14.02[a]	13.02[b]	
		Interaction(V*H)			
	Forward speed level	H_{25}	H_{50}	H_{75}	
	V_1	13.38[b]	15.65[a]	16.7[a]	1.82
	V_2	12.35b[c]	15.35[a]	12.7[b]	
	V_3	10.9[cd]	11.05[cd]	9.65[d]	

Means followed by the same letter (or letters) do not have significant difference at 5% level of probability.

As shown in Table 7, the index ranged from 66.25% to 76%. The highest value (76%) occurred at the lowest forward speed (V1) and one-fourth hopper fill level (H25), while the lowest (66.25%) occurred at the highest speed (V3) and a half-filled hopper (H50). The index decreased with increasing forward speed, a trend consistent with findings by Al-Gaadi & Marey (2011).

Effect of forward speed and hopper filling level on precision index

The forward speed of the planter on the precision index was significant at probability ($p < 0.05$), according to the analysis of variance (ANOVA). Nevertheless, the precision index was not significantly impacted by the hopper filling level or the interaction between forward speed and hopper filling level ($p > 0.05$). The effect of forward speed and hopper filling level on precision spacing index of planter performance is given in Table 8. The lowest precision index (12.63%) was obtained at lower forward speed. However, the maximum precision spacing index 17.53% was observed at highest level of forward speed. At the highest level of forward speed and maximum hopper filling level resulted in maximum precision spacing index. Lower values for the precision index indicate better performance compared to higher values of precision index (Kachman and Smith, 1995).

Table 7: Effect of planter forward speed and hopper filling level on quality of feed index (QFI)

Parameter		Source of variation			Measure of differences
	Forward Speed level	V_1	V_2	V_3	LSD (5%)
MI (%)		73.74[a]	73.65[a]	67.73[b]	1.82
	Hoper loading level	H_{25}	H_{50}	H_{75}	
		73.11[a]	70.5[b]	71.52[ab]	3.15
		Interaction(V*H)			
	Forward speed level	H_{25}	H_{50}	H_{75}	
	V_1	76[a]	72.95[b]	72.65[b]	
	V_2	75.72[a]	72.3[c]	72.55[bc]	
	V_3	67.6[d]	66.25[d]	69.35[d]	0.47

Means followed by the same letter (or letters) do not have significant difference at 5% level of probability.

Field Performance of Potato Planter

Depth of seed placement

The seed was placed uniformly in the furrow openers at an average depth of 6.94 cm. According to Ram (1975), a planting depth of 5 to 10 centimeters is required for the seed to contact a sufficiently wet layer for germination,

Table 8: Effect of planter forward speed and hopper filling level on precision index (PI)

Parameter		Source of variation			Measure of differences
	Forward Speed level	V_1	V_2	V_3	LSD (5%)
MI (%)		13.20[c]	15.51[b]	16.87[a]	0.47
	Hoper loading level	H_{25}	H_{50}	H_{75}	
		14.22[c]	15.32[b]	16.04[a]	0.81
		Interaction(V*H)			
	Forward speed level	H_{25}	H_{50}	H_{75}	

	V_1	12.63[d]	12.81[d]	14.15[c]	
	V_2	14.41[c]	15.68[b]	16.44[b]	
	V_3	15.63[b]	17.46[a]	17.53[a]	0.81

Means followed by the same letter (or letters) do not have significant difference at 5% level of probability.

which places the planter's depth within the desired range.

Height and width of ridge

Table 9 illustrates the height and width measurements of the ridges developed by the planter. The ridge's height ranged from 19.7 to 22 cm, with an average of 20.72 cm. The ridge's bottom width varied from 41.5 to 44.5 cm and average width of ridge was 43.67 cm and it did not vary between the ridges, which indicate the ridges are uniform.

Theoretical field capacity, Effective field capacity and Field efficiency

The field capacity and field efficiency of the tractor-drawn automatic mechanical potato planter are presented in Table 10. The planter achieved a mean effective field capacity of 0.151 ha/hr and a field efficiency of 84.09% at a forward speed of 1.5 km/hr. For comparison, Momin (2006) evaluated a semi-automatic potato planter and reported a theoretical field capacity of 0.27 ha/hr, an effective field capacity of 0.18 ha/hr, and a field efficiency of 66.67% at an operating speed of 1.5 km/hr. Similarly, Asheesh *et al.*, 2017 developed and evaluated an automatic potato planter, reporting an effective field capacity of 0.09 ha/hr and a field efficiency of 60.7% at an operating speed of 2 km/hr. The field efficiency of the potato planter in this study was within the acceptable level recommended for planters.

Fuel consumption

The planter was run at a speed of 1.5 km/h over a 0.126 hectare area. The time and fuel consumption for the test area was measured by refilling methods. The fuel consumption obtained was 1.20 lt/hr. (Momin, 2006) evaluated semi-automatic potato planter and reports that the fuel consumption of 1.5 lt/hr at operation speed of 1.5 km/hr.(Miressa,2019)

Table 10: Theoretical field capacity, Effective field capacity and Field efficiency

Plot no.	Speed (km/h)	Total time required (min)	Theoretical field capacity (ha/h)	Effective Field Capacity (ha/h)	Field Efficiency (%)
1	1.5	16.58	0.180	0.152	84.44
2	1.5	16.27	0.180	0.155	86.05
3	1.5	17.12	0.180	0.147	81.78
Avg.	1.5	16.66	0.180	0.151	84.09
Note: Size of plot = 50 × 8.4m and Width of Planter = 1.2 m					

Germination count

The mean seed germination percentage was 83.75% at a speed of 1.5 km/hr. This result revealed that the developed tractor operated functionally and satisfactorily.

Operating costs of planter

The estimated costs for the planter were determined based on its effective field capacity of 0.151 ha/hr at an operating speeds of 1.5 km/hr. As shown in Table 11, the cost of planting potatoes with the planter at this recommended speed was 14,233 birr/ha, requiring 3 man-days/ha. In comparison, the conventional method cost 18,000 birr/ha and required 40 man-days/ha. Therefore, the potato planter saved about 93% in labour and 21% in cost compared to the conventional planting method.

CONCLUSION

The mean seed spacing increased from 19.67 cm to 33 cm with higher forward speeds, with the specific spacing for potatoes ranging from 26.85 cm to 30.57 cm. The miss index (10.75% to 22.70%) rose with increased speed, while the multiple indexes (9.65% to 16.70%) decreased. The quality of feed index was 66.25% to 76.00%, and the precision index was 12.63% to 17.46%. An operational

Table 11: Estimated cost of potato planting

Cost item	Potato planter	Manual planting
a) Fixed cost		
Depreciation (Br/hr)	13.17	
Interest (Br/hr)	6.44	
Taxes (Br/hr)	1.50	
Insurance (Br/hr)	1.17	

Shelter (Br/hr)	1.17	
Subtotal fixed cost (Br/hr)	24.95	
b) Variable cost		
Labour cost	112.5 birr/hr	12,000 birr/ha
Repair & maintenance (Br/hr)	11.70	
Tractor hire cost (Br/hr)	2000	
Pair of oxen hire cost		6,000
Subtotal variable cost (Br/hr)	2124.20	
Grand total planting cost (Br/hr)	2,149.15birr/hr or 14233birr/ha	18,000 birr/ha

speed of 1.5 km/hr is recommended, as it optimally balanced seed spacing, a less than 1% seed damage rate, miss rate, and 84.09% field efficiency. At this speed, field capacity was 0.151 ha/hr with a fuel consumption of 1.2 l/hr. Field tests showed an 83.75% mean germination rate with seeds planted at an average depth of 6.94 cm, and the formed ridges met required dimensions.

The planter is efficient and economical, reducing planting costs by about 21% (14,233 vs. 18,000 Birr/ha) and saving approximately 93% in labour compared to manual methods. Its manufacturing cost was 35,118 Birr. The tractor-drawn planter is satisfactory but would benefit from future modifications, such as increasing the row count and adding a fertilizer application system, to enhance capacity and reduce costs.

Based on field evaluation, the tractor-drawn potato planter performed satisfactorily. Mean seed spacing ranged from 19.67–33 cm, with optimal performance for the selected variety achieved at 1.5 km/hr. This speed balanced a quality of feed index of 66.25–76%, minimal seed damage (<1%), a field efficiency of 84.09%, and achieved an 83.75% germination rate. The mechanical planter reduces planting costs by 21% (14,233 compared 18,000 Birr/ha) and labour by 93% compared to manual methods, proving its economic and operational efficiency. For wider adoption, it is recommended to use the specified 1.5 km/hr operational speed. Furthermore, to increase capacity and utility, future modifications should increase the row number from two to three and incorporate a fertilizer application system, which will further reduce operating costs.

The performance evaluations indicated that the planter can be used successfully on farms; however, the following issues must be addressed to make it popular, adaptable, and usable among farmers.

1. It is recommended that a field operational speed of 1.5 km/hr be used, as this speed is optimal with respect to seed spacing, miss rate, seed damage, and field efficiency.
2. Furthermore, to increase field capacity and reduce operating costs, future work should repeat this study with a planter that has an increased number of rows (from two to three) and an incorporated fertilizer application system.

REFERENCE

A.Al-Gaadi, K. (2011). Performance evaluation of a cup-belt potato planter at different operation conditions and tuber shapes.pdf. *American-Eurasian J.Agric.&Environ.Sci., 10*(5), 821–828.

Al-Gaadi, K. a., & Marey, S. a. (2011). Effect of Forward Speed and Tuber Characteristics on Tuber Spacing Uniformity for a Cup-Belt Potato Planter. *Middle-East Journal of Scientific Research, 8*(August), 753–758. http://www.idosi.org/mejsr/mejsr8(4)11/8.pdf

Asheesh, Kumar, V., Sharma, S., & Kumar, A. (2017). Design and Development of Automatic Potatao Planter for Mini Tractor. *International Journal of Scientific & Engineering Research, 8*(7), 13–28. http://www.ijser.org

Kibar, H. (2012). Design and Management of Postharvest Potato (Solanum Ruberosum l.) Storage Structures. *Ordu Üniv. Bil. Tek. Derg, 2*(1), 23–48. http://btd.odu.edu.tr/files/2012-3.pdf

M.A. Momin, M. R. I. S. and M. M. H. (2006). Field performance of a tractor• operated semi-automatic potato planter. J. Bangladesh Agril. *Univ, 4*(2), 391–399.

Miressa, S. B. (2019). Design and Development of AutomaticPotato Planter Sagni. *International Journal of Applied Science and Research Design, 2*(4).

Misener, G. C. (1979). RELATIVE PERFORMANCE OF CUP AND PICK TYPE POTATO PLANTERS Speed of the planter and intended seed piece constraints , some trials were completed after intended center-to-center plant distance . *A double was recorded when the space between adjacent seed pie. 21*(2), 131–134.

Singh, R.C, Singh, G., Saraswat, D.C., 2005. Optimization of design and operational parameters of a pneumatic seed metering device for planting cottonseeds. *Biosystems Engineering, 92*(4): 429–438

Vita and IPF (Irish Potato Federation), 2014. Potatoes in Development: A Model of Collaboration for Farmers in Africa. Pdf doc