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Verification and On-farm Evaluation of Tractor Drawn Rigder for potato Hiller

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ABSTRACT

Potatoes are hilled between canopy closure and emergence when cultivated commercially and traditionally. The conventional hilling technique used in potato farming is labor-intensive, slow, tedious, inefficient, and requires drudgery, all of which raise output costs. This study's objective was to modify and evaluate a ridger attachment for forming potato hills, which is pulled by a tractor and adjusted to specific, preset measurements operating speeds and spacing of row. A frog, tyne, primary frame, moldboard system of hitching, and share make up the manufactured ridger. With respect to the width of the ridge and the height of the ridge, plants' damage, power requirement, and draft requirement, field efficiency and capacity, cost of labor and ownership and operation, hillers' performance was assessed on sandy loam and vertisol soil types. Three levels of operating speed and two types of soil with three replications comprised the factorial, fully randomized experimental design. At tractor advance speeds of 2.5, 3, and 3.5 km/h, the implement was assessed. The operating speed of tractor and the type of soil had a significant impact on the ridge's height and width at $p < 0.05$. However, neither ridge height nor width were significantly affected by the combination of soil type and operating speed ($P < 0.05$). At a 2.5 km/h speed of operation and 94.54% efficiency of weeding, the mean values for fuel requirement, field efficiency, ideal and actual field capacity were 2.57 l/h, 91.93%, 0.39 ha/h, and 0.36 ha/h, respectively. Based on the performance evaluation results, it is determined that most farmers can utilize the fabricated potato ridger effectively and affordably.

INTRODUCTION

Ethiopia cultivates several tuber crops, one of which is the potato (Solanum tuberosum L.). According to CSA (2008/2009), approximately 1 million farmers plant it. Ethiopia offers the ideal climate and edaphic conditions for producing seed potatoes and high-quality ware. Potato production is suited to the 1800–2500 m elevation range, where approximately 70% of the accessible agricultural area is found. According to (FAO,2013) it covers 66,745 hectares of land and produces 784,993 tonnes of goods nationwide.

Because potatoes can produce and offers a dual advantage: high quality, abundant harvests relative to inputs, coupled with a growth cycle that is shorter than that of cereal crops like maize, Ethiopian farmers use potato cultivation primarily to provide a sufficient supply of food during times of food scarcity and to serve as a significant source of income (Adane H. *et al*., 2010). According to the Ethiopian government, potatoes are a staple crop which can improve both the nation's economy and surplus of food (EIA ,2012). It is one of the main exports of vegetables (EEI, 2015).

One of Ethiopia's prospective potato-growing regions is Arsi, which is located in the southeast. A substantial portion of the nation's potato demands are met by the production of field crops like potatoes. Despite the region's potential for the nation's high production and quality of potatoes, smallholder farmers' low productivity and crop production are severely impacted by a variety of issues. Properly hilling and earthening up is the most important tasks at the cultivation of potato stage. One of the problems is this.

The process of making a hill around a potato plant's base is known as hilling. In the production cycle, potatoes are hilled between canopy closure and emergence when cultivated commercially and traditionally. Using disks, sweep shovels, or other like instruments, one can hill by lifting soil from between rows and depositing it next to and on top of the row. Improved drainage, less tuber greening, higher soil temperature, and better weed control are some benefits of hilling. Cultivating, mulching, and earthening up are all conducted simultaneously in rainfed crops; in irrigated crops, earthening or hilling up is done two times or three times at the season of cropping in addition to side dressing of fertilizer and weeding. Earthing up often occurs 45–60, 90–105, and 120–135 days after planting (DAP). This intercultural process aids in the development and growth of finger rhizomes while ensuring enough root aeration. In addition, it inhibits the growth of weeds and shields the rhizome from scale insect attacks (Panigrahi *et al*., 1987). It was found that flat bed, earthening up, and careful control of each of these components were the finest ways to enhance the quantity and quality of potato tuber production(Ajai *et al*., 2002).

The nation's potato tuber producing regions still lack an appropriate hilling method for tractor farming methods. Rather, a pair of oxen-drawn mareshas, a short-handle hoe with slats, cutlasses, axe, cutlasses, spades, and further locally accessible implements are used in the

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traditional way of hilling potato fields. In potato farming, the traditional hilling method is labor-intensive, slow, tiresome, inefficient, and demands drudgery, all of which increase output costs.

At Asella Agricultural Engineering Research Center, a three-row soil ridger was created from the single-row ridging implement imported by the private company. The manufactured ridger tool consists of the frog, tyne, supporting frame, moldboard, system for hitching, and share. When assessing the performance of the implement, factors such as the width and height of the ridge, the damage to plants, the power requirements and draft requirements, the field efficiency and capacity, the cost of labor, and ownership and operation were all considered. The instrument was tested at 2, 2.5, and 3 km/h, according to the analysis. Fuel usage, field efficiency, ideal, and effective field capacity throughout a single season (potato planting season) were 1.5 l/h, 92.57%, 0.32 ha/h, and 0.30 ha/h at a speed of 2 km/h, and 93.63% of weeding efficiency. (Abulasan Kabaradin *et al.*, 2023)However, testing and assessing the prototype on various soil types and forward speeds for future potato planting seasons will make the tool flexible and dependable to use it and meet the needs of small scale farmers engaged in potato tuber cultivation. Thus, the perseverance of this project was to build, confirm, and evaluate an appropriate tractor-drawn potato rider for hilling operations.

Objectives

To verify and assess the tractor mounted ridger implement performance for a potato hiller

MATERIALS AND METHODS

Description of hiller parts

Locally available materials were used to construct the tractor-drawn potato hiller tool, which featured a primary frame, a hitching system, a frog, a share, and a Tyne.

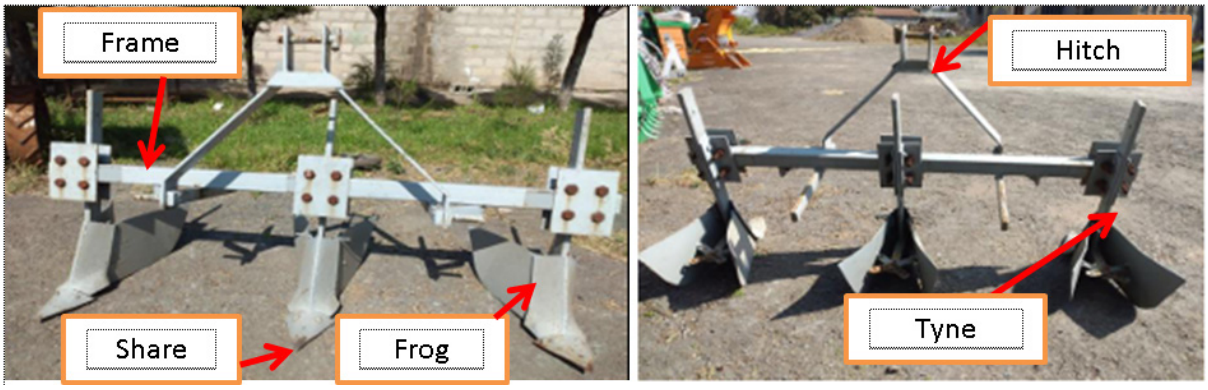

Figure 1: The prototype of potato hiller implement

Implement frame

The frame of the ridger is acts as its skeleton, supporting all other components. The amount of material required for the frame was determined by accounting for two design factors: material strength and weight. In this instance, the necessary strength was provided by a square hollow portion of mild steel that measured 60 x 60 mm with a thickness of 5 mm.

Tyne

It was fabricated from mild steel flat iron with dimensions of 730 x 60 x 20 mm in thickness to endure the load experienced during the hilling operation in actual field circumstances. Three number of tynes were fastened to ridger's central structure using bolts and nuts. The breadth and depth could be altered by moving the tynes vertically and horizontally, respectively. The tire's upper end was soldered on 100 × 100 mm x 6 mm thick MS sheet metal. Bolts and nuts were used to secure the tires to the main frame through holes in MS sheet metal.

Share

Its function is to slice into and cut through the soil beneath the surface. Using 6 mm thick MS sheet metal, the hiller's share was built as a slip type. The end tip of the share was shaped accordingly which forms a 30° angle with the horizontal.

Frog

It was fabricated from 4 mm thick mild steel sheet. The share and moldboard were then bolted to it and the upper portion of the landside. Draft force acts at the spade's angle during the ridging operation, causing a bending stress because the soil's resistance at the bended side causes the rod to twist. Soil resistance was calculated using the assumption that it is horizontal, acts along the shovel's axis of symmetry, and is 0.25 kg/cm2 for hefty soil.

The draft force acting on the tip of the share was determined with the following formula (Kurtz *et al.*, 1984).

$$D=K_o \times n \times w \times d \quad (1)$$

$$=[0.25\times3\times((2+6)/2)\times11]\times9.81$$

$$D=323.73\ N$$

Consequently, a safety factor of 3 was assumed, leading to the following calculation for the total draught on the shovel.

$$D=323.73\times3$$

Table 1: Specific soil resistances at a depth of 15 cm (Dubey, 2003)

Serial No	Soil type	Specific resistance (kg/cm2)
1	Light soil	0.12
2	Medium soil	0.15
3	Heavy soil	0.20
4	Very heavy soil	0.25

D=971.2 N

Draft force per opener was calculated using the following equation:

D=971.2/3 N

323.73 N

Where:

D = draft force, N

K_o= soil resistance, (m^3)

W= opener width, (cm)

d= Opener depth, (cm)

n= the total number of furrow openers

Therefore, a four-sided (square) hollow mild steel gulley opener with dimensions of 730 mm x 60 mm and a 20 mm wall thickness was selected. This size was deemed to have an adequate safety factor and was readily available on the market.

Hitching system design

The hydraulically controlled three-point linkage at the back of the tractor was used to mount a potato hiller. Key geometric dimensions—mast height, lower hitch point span, mast specifications, and linch pin hole distance—were computed.

Performance Assessment and Evaluation

Tests of field performance were conducted towards evaluate the implement's overall performance and working capability. The Munessa areas of the Arsi Zone were used for the tractor-drawn potato hiller field tests. The following data were recorded during field trials: plant height, soil moisture content, bulk density, ridging width, ridge height, operating speed, total hilling area, total operating time, and the number of damaged plants.

Figure 2: Field performance assessment

The soil's moisture content

Bulk density and moisture content of soil were determined from five randomly collected samples at a 25 cm depth before hilling operations began. Following the standard gravimetric method (Jaimin and Rangapara, 2014), the trials were balanced, oven-dried at 105°C for 24 hours, and re-weighed to calculate the soil moisture content.

$$Mc=Ww-Wd/Wd \qquad (2)$$

Where,

Mc = Soil moisture content, %;

Ww = Weight of soil before drying, g; and

Wd = weight of soil after dried, g.

Bulk density of soil

The bulk density was determined by dividing the weight of oven-dried soil (at 1050C for 24 hr) samples by the volume it occupied and calculated by using the following equation given below (Rangapara & Jaimin, 2014).

$$\varrho_b = M/V \qquad (3)$$

Where,

ϱ_b = bulk density of soil, g/cm^3

M = oven dry mass of soil, gm; and

V = volume of the core sampler, cm^3

Plant height

Using a measuring tape, we randomly measured the potato plant height five times during the hilling operation.

Theoretical Field Capacity

The speed and theoretical width of the implement determined the theoretical field capacity. It was the rate of field coverage that would be attained if implements consistently covered 100% of their rated breadth and carried out their function 100% of the time at the specified speed. The theoretical field capacity was computed as given by Kepner *et al.*, (2005).

$$TFC = W \times S/10 \quad (4)$$

Where, TFC = Theoretical Field capacity, ha/h
S = Speed of operation, km/hr, and
W = Theoretical width of implement, m

Actual field capacity

To calculate effective field capacity, the time taken for real work and the time used for additional operations such as turning, cleaning, machine adjustment, and addressing machine trouble were taken into consideration. The area covered throughout the operation was computed, and the plot's length and width were measured. The actual field capacity, which represents the actual average rate of coverage by the implement, was then computed based on the area covered per hour. The total time required to finish the operation was recorded, and effective field capacity was determined using the approach published by Kepner *et al.* (2005)

$$EFC = A/T_p + T_I \quad (5)$$

Where: EFC = Effective field capacity, ha/hr
A = Actual area covered, ha
T_p = Productive time, hr, and
T_i =Non-productive time, hr

Machine Field efficiency

The field efficiency is the ratio of the effective field capacity to the theoretical field capacity, usually measured in terms of percentage. It includes the effect of time lost in the field and of failure to utilize the full width of the machine (Kepner *et al.*, 2005).

$$FieldEfficiency = Effectivefieldcapacity/Theoreticalfieldcapacity \times 100 \quad (6)$$

Draft Force and Power Requirement

The draft force and draft power of a ridger was essential for ensuring tractor compatibility and enhancing performance. The dynamometer was connected between an auxiliary tractor and the tractor with the implement. With the implement tractor in neutral, the auxiliary tractor pulled the assembly. Draft was recorded over a 20-meter distance in the operating position. The net draft force was calculated as the difference between this reading and a baseline reading taken with the implement raised off the ground.

Draft Force

The horizontal force needed to pull the tool through the soil is known as draft force (F_x). The type of soil, the type of implement, the working width and depth, and the operating speed all play a role. Draft force was determined using an empirical formula, according to the American Society of Agricultural and Biological Engineers (ASABE):

$$F_d = F_i \times W \times d \times \{1 + (2.3v/100).\{1 + (0.25W_{res}/W)\} \quad (7)$$

Where: F_d = Draft force (N), F_i = Soil-specific draft parameter (6 N/cm² for sandy soil, 6 up to 10 N/cm² for clayey soil), W = working width (cm), d = working depth (cm), v = speed (km/hr), W_{res} = residue cover (% by weight, 0 if negligible).

Determination Draft Power

Draft power (P_x) is the power needed to overcome the draft force at a given speed. The draft demand of the tractor-operated multi-crop row inter-cultivator was evaluated according to the following equation published by Parmar & Gupta (2016):

$$P_d = F_b \times V/3.6 \quad (8)$$

Where: P_d = draft power required to pull the implement (kW), Fd = draft force (kN), V = Speed of operation (km/hr).

Determination of Tractor Power

The engine power (P_e) must be higher than draft power because to inefficiencies (traction loss, transmission loss, etc.). Thus, the following formula provided by Srivastava *et al.* (2006) was used to calculate the tractor power needed for the operation of a multi-crop row inter-cultivator:

$$P_e = P_d/\eta \quad (9)$$

Where: η = Tractive efficiency (0.6 up to 0.8 for the recommended wheeled tractors, for the calculation η = %), P_d = draft power (kW).

Fuel consumption

Fuel consumption, a key economic factor for the hilling machine, was measured using the top-fill method. The procedure involved filling the fuel tank to a set level before testing. After operation, the volume of fuel needed to refill the tank to that same level was measured, determining the total consumption for the test. This measurement was then used to calculate the hourly (l/hr) or per-hectare (l/ha) fuel consumption rate, following the method of Nkakini *et al.*, (2010).

$$FC = FR/A \quad (10)$$

Where: Fc= fuel consumption (l/ha)
fr= Re-filled quantity of fuel (l), A= Cultivating area (ha)

Weeding Efficiency

The weed count method was used to measure the length of the row at 5 meters. The field was marked, and the total number of weeds and stubbles contained within the indicated length range was counted before and after the test run on the same row. Within the test plot, five observations were made at random. The weeding efficiency was calculated as follows

$$Weeding\ efficiency(\%) = w_1 - w_2/w_1 \times 100 \quad 11)$$

Where,
W_1 = The total number of weeds was assessed by counting all weeds within each 5-meter row section before ridging and
W_2 = The total number of weeds was assessed by

counting all weeds within each 5-meter row section after ridging.

Ridge height and width measurements

Ridge width and height were determined at predefined tractor speeds of 2.5, 3.0, and 3.5 km/h. The lifting mechanism was adjusted at each speed to achieve the target depth of cut. For each speed, five random measurements were taken. The ridge height (i.e., depth of cut) was determined the vertical distance from the furrow base to the ground surface using a tape measure.

Plant Damaged

During hilling, plant damage was assessed at three different forward speeds. The proportion of damaged plants was counted within a selected row for each speed.

Cost estimation

The yearly and hourly costs of operations for the tractor and the manufactured hiller were calculated in Ethiopian currency following to the methodology of previously done work (Wen-yuan Huang *et al.*, 1979). The calculation included the capital cost, capital interest, maintenances and replacement parts, labour, and devaluation. The economic life of tractor was assumed to be 10 years, with an annual usage of 260 hours.

Fixed Cost

Depreciation cost (D): Depreciation, which measures the decrease in the implement's value over time, was determined as bellows (Kepner *et al.*, 2005).

$$D=(C-S)/UL \quad ,(EB/hr) \tag{12}$$

Capital Interest (I): capital interest was computed based on implement's mean asset value, considering its first-year and final-year worth, using the following equation (Kepner *et al.*, 2005).

$$I=((C+S)/2U) \times 0.12 \quad ,(ETB/hr) \tag{13}$$

According to Srivastava *et al.* (2006), the costs for shelter, insurance, and taxes were calculated as 2% of the primary asset.

The sum of all fixed costs = (a+ b + c)

Variable costs of hilling implement

a) The fuel expense was determined by multiplying the per-liter fuel price by the tractor's fuel consumption at optimal implement performance.

Repair and maintenance costs, calculated as 5% of the initial investment, were derived using Equation 13. (Kepner *et al.*, 2005).

$$R=(C \times 2\,\%)/UL,(ETB/hr) \tag{14}$$

Labor wages: Labour wages were computed according to the standard hourly pay rate.

$$LW=DW/H,(ETB/hr) \tag{15}$$

Total variable cost = (d + e+ f)

The total hourly cost of ridging was calculated as the sum of the fixed and variable costs per hour. Finally, the operating cost per unit area was determined by multiplying the total hourly cost by the implement's average effective field capacity.

Where: D = depreciation (EB/hr),
C = investment price (EB/hr)
S = salvage value 10% of initial cost,
R = repair and spare parts costs,
L= estimate life (hr) (10 years),
I = interest on capital (ETB/hr),
LW = labor wages,
H= annual operating hours,
U = the implement's yearly operational hours,
DW = daily labor wage.

Experimental Design

The experiment used a 3^3 factorial design in a completely randomized layout with three replications. The factors were forward speed (2, 2.5, and 3 km/hr) and soil type with three levels. This resulted in a total of 27 experimental runs.

Data Analyzing

Statistical analysis was performed with GenStat 15th edition. Following Gomez and Gomez (1984), an analysis of variance (ANOVA) suitable for the experimental design was conducted. For factors showing significant effects in the ANOVA, treatment means (e.g., for ridge height and plant damage) were compared using the Least Significant Difference (LSD) test at the 5% level to assess the influence of variables such as forward speed.

RESULTS AND DISCUSSION

Soil moisture content

Five random soil trials were collected using a core sampler at a depth of 25 cm prior to hilling. As indicated in Table 1, the average soil moisture content at 25 cm was 19.75% for sandy loam and 20.44% for vertisol (clay) soil.

Soil Bulk Density

Five random samples were taken from the 0-25 cm depth in the experimental plot using a core cutter. Every sample was weighed, oven-dried for 24 hours at 105°C, and then weighed once again. The resulting average bulk density was 1.41 g/cm³ for sandy loam and 1.39 g/cm³ for vertisoil, as detailed in Table 1.

Actual Field Capacity and Field Efficiency of Potato Ridger

The ideal and actual field capacities of the ridger both increased with operational speed, as detailed in Table 2 and illustrated in Figure 1. At forward speeds of 2, 2.5, and 3 km/h, the theoretical field capacity was 0.32, 0.39, and 0.45 ha/hr, correspondingly, while the actual field capacity was 0.30, 0.36, and 0.41 ha/hr. This translates to a working time of 2.44 to 3.33 hours per hectare.

However, field efficiency declined as speed increased. The highest efficiency of 92.55% was observed at 2 km/h, decreasing to a low of 89.22% at 3 km/h (Table 2, Figure **According to (Rangapara, D., & Jaimin, P. 2014),**

Table 1: Field soil properties (dry basis): moisture content and bulk density.

Rep.	Moisture content of soil, %		Soil bulk density,g/cc	
	Sandy Loam soil	Vertisol soil	Sandy Loam soil	Vertisol soil
1	18.2	18.76	1.42	1.44
2	18.76	19.28	1.48	1.39
3	20.93	21.81	1.4	1.38
4	21.1	21.96	1.35	1.37
5	19.78	20.41	1.38	1.37
Mean	19.75	20.44	1.41	1.39

Table 2: Average field performance

width, m	Length of plot, m	Operating Speed, km/h	Fuel Consumption(l/hr)	TFC, (ha/hr)	EFC, (ha/hr)	FE,%
1.55	50	2.00	1.88	0.32	0.30	92.55
1.55	50	2.50	2.57	0.39	0.36	91.93
1.55	50	3.00	3.34	0.45	0.41	89.32

as the field's size reduced, the implement's number of passes rose as well, increasing time losses and producing poorer field efficiency ratings. The reduction in theoretical time compared to the other test plots was the primary cause of the decline in field efficiency via increasing operational speed.

Fuel requirement

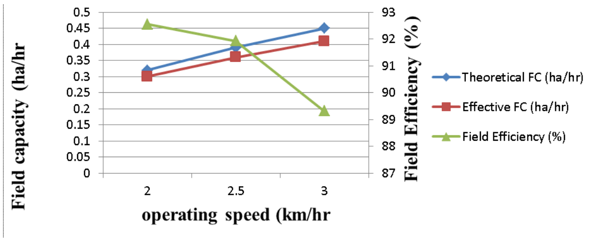

Figure 1: Impact of forward speed on theoretical field capacity, effective field capacity, and field efficiency.

The results indicated that mean fuel consumption increased with operating speed, as shown in Table 5. Consumption was recorded at 1.88, 2.58, and 3.37 L/hr at speeds of 2, 2.5, and 3 km/hr, correspondingly. This finding is consistent with the 3.83 L/h reported by Raghavendra *et al.*, (2013) at a comparable speed.

Power and draft measurement

Draft force for the potato hiller was determined with a digital dynamometer. As shown in Table 3, the mean draft increased with operating speed on both soil types. On sandy loam soil, draft forces were 651.87 N, 687.27 N, and 694.53 N at 2, 2.5, and 3 km/h, respectively. Similarly, on vertisol, the forces were 660.70 N, 693.33 N, and 696.07 N at the same speeds. The maximum draft of 696.07 N was recorded at 3 km/h on vertisol, while the minimum of 651.87 N occurred at 2 km/h on sandy loam.

The energy required to operate the implement was determined from the forward speed and draft. On sandy loam soil, the power requirement was 0.48, 0.64, and 0.77 HP at 2, 2.5, and 3 km/h, correspondingly; on vertisol, it was 0.49, 0.64, and 0.78 HP at the same speeds. As illustrated in Figure 2, both draft and power requirements increased marginally with operational speed.

Table 3: Draft and power required

Speed (km/hr)	Soil type	Net draft (N)	Power required (Hp)
2	Sandy Loam	651.87	0.48
	Vertisol	660.70	0.49
2.5	Sandy Loam	687.27	0.64
	Vertisol	693.33	0.64
3	Sandy Loam	694.53	0.77
	Vertisol	696.07	0.78

The energy required to operate the implement was determined from the forward speed and draft. On sandy loam soil, the power requirement was 0.48, 0.64, and 0.77 HP at 2, 2.5, and 3 km/h, correspondingly; on vertisol, it was 0.49, 0.64, and 0.78 HP at the same speeds. As illustrated in Figure 2, both draft and power requirements increased marginally with operational speed.

Influence of forward speed on ridge geometry (height and width)

The hill dimensions were significantly affected by both forward speed and soil type ($p < 0.05$), but not by their interaction, as shown by the ANOVA in Table 4. As operating speed increased from 2 to 3 km/h, a consistent trend was observed: ridge width increased while ridge

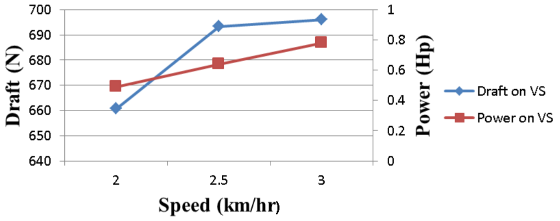

Figure 2: Tractor linear speed's effects on power and draft

height decreased. This resulted in a broader, flatter ridge profile rather than a conical shape, as the disturbed soil deformed into a flat tip at higher speeds (Figure 3).

On sandy soil, ridge width increased from 39.67 cm to 43.73 cm, while height decreased from 30.67 cm to 27.33 cm. Similarly, on vertisol, width increased from 37.50 cm to 42.70 cm, and height decreased from 32.67 cm to 29.33 cm (Table 5). These results are consistent with the observations of Makki and Suleiman (2008).

Weeding Efficiency

Table 4: Main influence of operational speed and soil type on potato ridge dimensions (height and width).

Speed Level (km/hr)	width (Cm)	height (Cm)
V2	38.58c	31.67a
V2.5	40.93b	29.50b
V3	43.22a	28.33c
Soil types		
SL	41.80a	28.78b
VS	40.02b	30.89a
LSD (5%)	0.63	0.74
SE(M)	0.60	0.71
CV (%)	1.48	2.37

Means sharing the same letter(s) are not significantly different at the 5% probability level.

Table 4: Main influence of operational speed and soil type on potato ridge dimensions (height and width).

Speed level (km/hr)	Soil types	width (Cm)	height (Cm)
V2	SL	39.67d	30.67b
V2	VS	37.50e	32.67a
V2.5	SL	42.00b	28.33d
V2.5	VS	39.87c	30.67b
V3	SL	43.73a	27.33e
V3	VS	42.70a	29.33c
LSD (5%)		1.1	1.3
SE(M)		0.60	0.71
CV (%)		1.48	2.37

Means followed by the same letter (or letters) do not have significant difference at 5% level of probability. Where; SL= sandy loam, VS= vertisol, LSD= least significance difference, SE(M)=standard error of the mean, CV= coefficient of variation

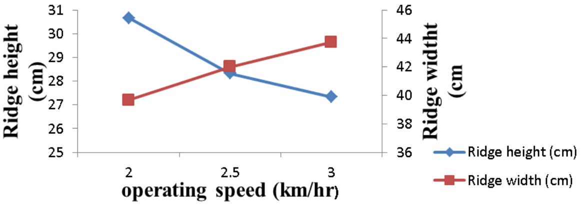

Figure 3: Impact of forward speed on potato ridge geometry (height and width).

In addition to soil hilling purpose, tractor-drawn potato ridgers are also used for weeding. The quantity of weeds before and after the weeding process was used to calculate the weeding effectiveness. Weeding effectiveness for potato hillers was found to be 94.54% on average.

Plant Damaged

During ridging operation at various operating speeds, the percentage of plant damage was noted. At 2, 2.5, and 3 km/h, respectively, the average percentage of plant damage was 1.92, 1.96, and 3.33. The harm to these plants increased as the speed of operation increased. Depending on the operator's experience and the close spacing between the root sections that the tool disturbed during operation, the plant may also sustain injury.

Cost Estimation

The operational cost for hilling potatoes using a tractor-drawn ridger was derived from its fixed and variable components. With a manufacturing cost of 1,248.13 Birr, the fixed cost amounted to 80.86 Birr/hr and the variable cost to 178.78 Birr/hr.

Based on specialist input, annual ridger use was estimated at 260 hours (33 operational days at 8 hours/day). The annual coverage area was derived by multiplying these annual operating hours by the implement's effective field capacity.

CONCLUSION

Soil type and operating speed significantly ($p < 0.05$) influenced ridge dimensions. As speed increased from 2 to 3 km/h, ridge width increased while height decreased. An operational speed of 2.5 km/h is recommended to achieve the optimal ridge profile of 28.33 cm in height and 42 cm in width. Both theoretical and effective field capacity increased with speed, reducing the working time per hectare from 3.33 hours at 2 km/h to 2.44 hours at 3 km/h. However, field efficiency decreased with increasing speed, peaking at 92.55% at 2 km/h and dropping to 89.32% at 3 km/h.

Overall, the implement proved to be an economical, efficient, and viable technology for potato hilling. The trade-off between capacity and efficiency must be considered when selecting the operating speed.

Recommendations

The implement's performance test demonstrates that it is capable of carrying out hilling operations at the farm level. However, in order to increase the tool's usability, popularity, and adaptability among farmers, the following problem needs to be resolved.

Based on the promising results obtained from field experiments, it is recommended that, the implement needs further demonstration to potato producing farmers.

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