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Full-Length Research Paper

Performance evaluation of a tillage multi-purpose farm tool on three different soils

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ABSTRACT: Tillage operations cannot be understated in agricultural practices, thus the need to evaluate the performance of a tillage multi-purpose farm tool. The goal of this research was to investigate the speed, efficiency, and cost implications of a tillage multi-purpose farm tool, when used for ploughing, weeding, and leveling, on three different soils. These three (3) operations were performed on loamy, sandy, and clay soils; physical and digital observations were used to collect data, which was then statistically analyzed using ANOVA. During weeding operations, the multi-purpose tool had a mean speed of 0.028m/s, 0.022m/s, and 0.018m/s and an efficiency of 90.4 %, 80.8 %, and 78 % on loamy, sandy, and clay soil, respectively. When comparing the multipurpose tool during ploughing operations, the machine had a mean speed of 0.028m/s, 0.022m/s, and 0.019m/s, with an efficiency of 82.4 %, 75.6 %, and 68.8 % on loamy, sandy, and clay soil, respectively, while when comparing the multipurpose tool during leveling operations, the machine had a mean speed of 0.050m/s, 0.041m/s, and 0m/s. When the machine was used on each of the three different soils, statistical analysis revealed that the effect of efficiency and speed were both significant. The cost of using the tool was ₦2,000 per hour, which is significantly less than the ₦ 5,000 per hour charge for crude manual labor. The efficiencies are considered adequate for this study and can be improved with additional research. The results obtained, as well as the ease of use of this device, indicate that it is more suitable and cost-effective for gardening than the crude hand methods.

Keywords: Ploughing, weeding, leveling, efficiency, speed

INTRODUCTION

Recent research has shown that by using scientific farming methods, we can achieve maximum yield, potentially saving a farmer from bankruptcy. But majority of farmers still uses primitive method of farming technique due to lack of knowledge or lack of investment for utilizing modern equipment (Kiran et al., 2017). A combination tillage implement helps to reduce drudgery by reducing time, labor, and fuel costs for seed bed preparations (Inthiyaz et al., 2020). The need for mechanization in Nigeria must therefore be assessed in light of a better understanding of the activities of small-holder farmers and the value farm power generates for them (Hiroyuki and Shehu, 2010). The most important factor influencing agricultural commodity productivity is the efficient use of available resources and the timeliness of agricultural operations. Conventional tillage involves multiple passes across a field with various turning and soil-pulverizing equipment, such as a mouldboard plough, discharrow, spike-toothed harrows, and cultivators. Such conventional tillage operations necessitate costly machinery and high fuel consumption, and they also contribute to soil compaction (Inthiyaz et al., 2020).

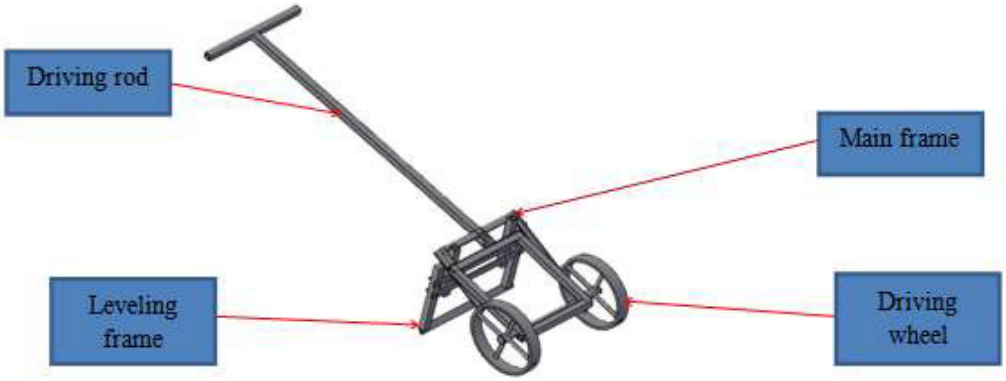

Figure 1: Isometric view of the machine.

As a result, a simple multi-purpose farm tool is required.

MATERIALS AND METHODS

Materials

The materials used for this study include; clay soil, loamy soil, sandy soil, stop-watch, weighing scale, metre rule and statistical analysis package.

Methodology

The Functional requirements of the machine include; proper and easy secondary weeding and tillage operations on a cultivated land.

Weeding

It is an act of removing unwanted plants during land preparation. Effective weed management is critical to maintaining productivity (Ahmed et al., 2010; Verma, 2014).

Ploughing

The word “plough” is most important agricultural implement since the beginning of history, used to turn and break up soil, to bury crop residue and to control weed.

Land Leveling

Land leveling is used for the spreading the soil surface after ploughing and it also helps in covering the soil surface after planting. In those lands with less accurate leveling operation and high unevenness, 30% of irrigation water is wasted (Asif et al., 2003). Figure 1 above shows a pictorial view of the machine.

Performance test

The multipurpose farm tool was used to carry out secondary weeding, ploughing, and leveling on a loamy, sandy and clay soil to evaluate its effectiveness on each. Testing of the tool was done in three (3) phases to observe each of the three (3) attachments. Firstly, the machine was used for weeding operations on loamy, clay and sandy soil; the ploughing parts was later attached and then used for ploughing operations; lastly, the leveling parts were attached and leveling operations were carried out. The time to carry out each test was recorded and replicated five (5) times for each operation.

Evaluation parameters

This includes the working speed, efficiency and labor cost of the machine.

The working speed is the distance covered over a given time.

Mathematically V= d/t (1)

Where

V working speed (m/s),
d= distance covered (m),
t = time (s)
Worked upon per hour) = L1 x B1 (2)

Table 1: Comparison of speed and efficiency of the machine when used for weeding.

S/N	Loamy		Sandy		Clay		Cost/hr ₦
	Speed (m/s)	Efficiency (%)	Speed (m/s)	Efficiency (%)	Speed (m/s)	Efficiency (%)	
1	0.028	92	0.023	84	0.020	79	
2	0.027	92	0.023	84	0.020	78	
3	0.028	90	0.021	82	0.020	78	
4	0.029	90	0.021	79	0.018	79	
5	0.028	88	0.020	79	0.018	76	
Mean	0.028	90.4	0.022	80.8	0.019	78	2,000
S.D	0.001	1.67	0.001	2.51	0.001	1.22	

Table 2: Statistical analysis on the comparison of speed and efficiency of the machine when used for weeding.

		SS	df	MS	F	P
Efficiency	Between	422.933	2	211.467	59.977	0.000
	Within	42.310	12	3.526		
	Total	465.243	14			
Speed	Between	0.000	2	0.000	105.000	0.0000
	Within	0.000	12	0.000		
	Total	0.000	14			

Table 3: Comparison of speed and efficiency of the machine when used for Ploughing.

S/N	Loamy		Sandy		Clay		Cost/hr (₦)
	Speed (m/s)	Efficiency (%)	Speed (m/s)	Efficiency (%)	Speed (m/s)	Efficiency (%)	
1	0.028	82	0.023	76	0.020	70	
2	0.028	82	0.023	77	0.020	70	
3	0.027	80	0.021	75	0.020	70	
4	0.027	80	0.021	75	0.018	67	
5	0.028	88	0.020	75	0.018	67	
Mean	0.028	82.4	0.022	75.6	0.019	68.8	2,000
S.D	0.001	3.29	0.001	0.89	0.001	1.64	

A2 (total area per hour) = L2 xB2 (3)

Efficiency (%)

The efficiency of the machine was calculated using the equation:

$$Efficiency = A1/A2\,X\,100 \quad (4)$$

Where
A1 (area)
L = Length/distance covered (m),
B = width of attachment (m)

Labor cost

The cost of using the manual method was calculated per sqm area and the equation below was us:

$$Cost\ per\ unit\ area = \frac{cost per hour}{area\ covered} \quad (5)$$

RESULTS AND DISCUSSION

Tables 1 and 2 compare the multi-purpose tool on loamy, sandy, and clay soils, as well as their statistical analysis; during weeding operations, the machine had a mean speed of 0.028m/s, 0.022m/s, and 0.018m/s, with an efficiency of 90.4%, 80.8%, and 78% on loamy, sandy, and clay soils, respectively. When used for weeding, statistical analysis revealed that efficiency and speed have a significant effect on the soils. This indicates that the multipurpose tool worked best on loamy soils. Tables 3 and 4 show a comparison and statistical analysis of the multipurpose tool during ploughing operations on loamy, sandy, and clay soils, respectively; the machine had a

Table 4: Statistical analysis on the comparison of speed and efficiency of the machine when used for ploughing.

		SS	df	MS	F	P
Efficiency	Between	462.400	2	231.200	48.484	0.000
	Within	57.223	12	4.769		
	Total	519.623	14			
Speed	Between	0.000	2	0.000	105.000	0.000
	Within	0.000	12	0.000		
	Total	0.000	14			

Table 5: Comparison of speed and efficiency of the machine when used for Leveling.

S/N	Loamy		Sandy		Clay		Cost/hr (₦)
	Speed (m/s)	Efficiency (%)	Speed (m/s)	Efficiency (%)	Speed (m/s)	Efficiency (%)	
1	0.051	97	0.043	95	0.020	79	
2	0.050	97	0.040	93	0.020	78	
3	0.050	95	0.040	93	0.020	76	
4	0.050	95	0.041	92	0.018	76	
5	0.048	95	0.040	92	0.018	76	
Mean	0.050	95.8	0.041	93	0.019	77	2,000
S.D	0.001	1.09	0.001	1.22	0.001	1.41	

Table 6: Statistical analysis on the comparison of speed and efficiency of the machine when used for leveling.

		SS	df	MS	F	P
Efficiency	Between	1,028.800	2	514.400	330.832	0.000
	Within	18.658	12	1.555		
	Total	1,047.458	14			
Speed	Between	0.003	2	0.001	1,271.667	0.000
	Within	0.000	12	0.000		
	Total	0.003	14			

mean speed of 0.028m/s, 0.022m/s, and 0.019m/s and an efficiency of 82.4 %, 75.6 %, and 68.8 % on loamy, sandy, and clay soils. When the machine was used for plowing, statistical analysis revealed that efficiency and speed have a significant effect. Tables 5 and 6 show a comparison and statistical analysis of the multipurpose tool during leveling operations on loamy, sandy, and clay soils, respectively; the machine had a mean speed of 0.050m/s, 0.041m/s, and 0.019m/s and an efficiency of 95.8 %, 93 %, and 77 % on loamy, sandy, and clay soils. When the machine was used for leveling, statistical analysis revealed that the effect of efficiency was significant.

Conclusion

The machine was simple to operate. The machine's operations were compared on different soils, and it was discovered that it performed best on loamy soil, and that the multipurpose tool was more effective, faster, and cost-effective than the crude hand method. The results above demonstrated that the machine performed best when used for leveling and worst when used for plowing. The cost of using the tool was ₦ 2,000 per hour, which is significantly lower and more economical than the ₦5,000 per hour charge for crude manual labor. The efficiencies are considered adequate for this study and can be improved with additional research.

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