EVALUATION OF TWO-WHEEL POWER TILLER THROUGH DRAWBAR PULL TEST

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ABSTRACT

The drawbar pull test for two-wheel power tillers evaluates their ability to create sufficient tractive force, ensure efficient operation, and reduce energy consumption. The drawbar pull test is an important evaluation method for agricultural machinery, particularly two-wheel power tillers. This abstract presents a comprehensive description of the drawbar pull test for two-wheel power tillers, emphasizing its importance, technique, and consequences for agricultural operations. The investigation was conducted in September 2023 at the National Agriculture Machinery Centre (NAMC) in Kamphaeng Saen, Thailand. In this investigation, the K120 Kubota power tiller was used to assess its drawbar power and wheel slide. The experiment was performed via the Asian and Pacific Network for Testing of Agricultural Machinery (ANTAM) test code. It was found that the maximum drawbar pull power at gear 1 was 0.8408 PS at 235 kgf force while at gear 2 was 1.285 PS at 292 kgf force. The wheel slip was 22.54% at maximum force in gear 1 while in gear 2, the wheel slip was 32.2% at maximum force.

Keywords: Power tiller, drawbar, pull test

INTRODUCTION

The agricultural sector in Malaysia contributes significantly for the country's economic growth as it increases GDP, generates employment, and maintains food security. With a wide range of industries including aquaculture, fisheries, and crops like rubber and oil palm, the sector has the potential to expand and greatly increase the country's GDP. The majority of farmers in the industry are smallholders, but they face difficulties like low productivity and a manpower shortage (Engku Elini et al., 2023). Modernization initiatives are required to boost growth. These initiatives should encourage the adoption of cutting-edge instruments and technology, improve infrastructure, and support sustainable practices.

Plant cultivation requires preparing the land, and using ordinary equipment like a power tiller has been shown to improve the quality of ploughing and boost grain yield. Traditional manual techniques of soil preparation and cultivation are being replaced by the multifunctional power tiller, an agricultural machine. Its engine-driven system minimizes costs, increases efficiency, and shortens the time needed to prepare the ground. The versatility of power tillers is emphasized by Krishnadas R and Renganathan R. (2022), who note that it increases agricultural productivity and lowers costs.

Because of their affordability and adaptability, power tillers are essential to the world's agricultural industry, especially in regions with small to medium-sized farms (Fasola et al., 2007). Power tillers are extensively utilized in India, particularly by small and marginal farmers, for various operations such as planting, weeding, harrowing, and plowing (Krishnadas R, Renganathan R, 2022). China has more than 1000 manufacturers and a sizable market, which helps to mechanize farming (Shiqing Lu et al, 2019). Power tillers are essential for effective soil preparation and crop management in Southeast Asia as well as other locations such as Africa, Latin America, Europe, and North America. They are perfect for modest landholdings because to their compact nature. Power tillers' ease of use enables operators to perform on-the-spot repairs.

One of the key factors in choosing the best and most appropriate agricultural gear is power output. The drawbar pull test is commonly used to compare or assess tractors or other machinery, including power tillers, according to De Almeida Montero. The drawbar pull test was used in this study to determine the power tiller's maximum force. The main objective of drawbar pull tests on different cars is to find the maximum towing force that can be applied at different speeds for different car configurations, weights, and drive train combinations.

MATERIALS AND METHODS

The experiment took place at the National Agricultural Machinery Centre (NAMC) situated on the Kasetsart University Khampang Saen campus. The testing methodology aligned with the guidelines outlined in the Asian and Pacific Network for Testing of Agricultural Machinery (ANTAM) test code for power tillers. A Kubota power tiller equipped with the RK 125-2 water-cooled diesel engine, boasting a maximum power output of 9.33 KW, served as the subject for the drawbar pull test. This power tiller was affixed to a 40hp tractor, which functioned as the load-carrying vehicle. Two optical tachometers were affixed respectively to the main pulley and gearbox pulley of the power tiller to monitor their rotations. The tension during the test was measured using a Kyowa LU-2TE load cell capable of accurately measuring forces up to 20 kN with a precision of 0.2%. This load cell was connected to the cable and secured between the power tiller and the tractor. All measurement instruments were linked to a data logger positioned behind the tractor for streamlined data collection and analysis.

The experiment took place on a regular road within the NAMC compound, where a 20-meter measurement zone was demarcated using four poles, as illustrated in Figure 1. Prior to commencing the experiment, the weight of the power tiller was measured both with and without the driver. Subsequently, the distance covered by the wheels over ten revolutions without any load was measured to determine the wheel slip. In the initial phase of the experiment, gear number 1 of the power tiller was engaged. The tractor operator adjusted the drawbar pull force and ensured its maintenance throughout the measurement area. As the power tiller initiated pulling the loaded car through the experimental zone, the moment it traversed the designated area was recorded. Concurrently, data pertaining to the load cell, engine, and transmission speed were logged. The experiment iterated through different drawbar pull forces in both first and second gears until reaching the maximum power. Belt slip, wheel slip, and drawbar power were subsequently calculated using the provided equations:

Belt slip (%) = $(\propto Ne - Nt)/(\propto Ne)$ X100

Where $\propto$ = Reduction ratio between transmission case and engine (Pulley diameter of engine for that transmission
Ne = Engine speed (rpm)
Nt = Transmission speed (rpm)

Wheel slip (%) =$((\beta Nt \times (Lt/60)) - V) / (\beta Nt \times (Lt/60))$X100

Where β = Reduction ratio of transmission between input shaft and axle shaft
Nt = Transmission speed (rpm)
Lt = Travelling distance for one revolution of tire without load (m)
V = Travelling speed (m/s)

Drawbar power (PS) = F X (V/75)

Where F: drawbar load (kgf)
V : travelling speed (m/s)

Figure 1: Experimental layout

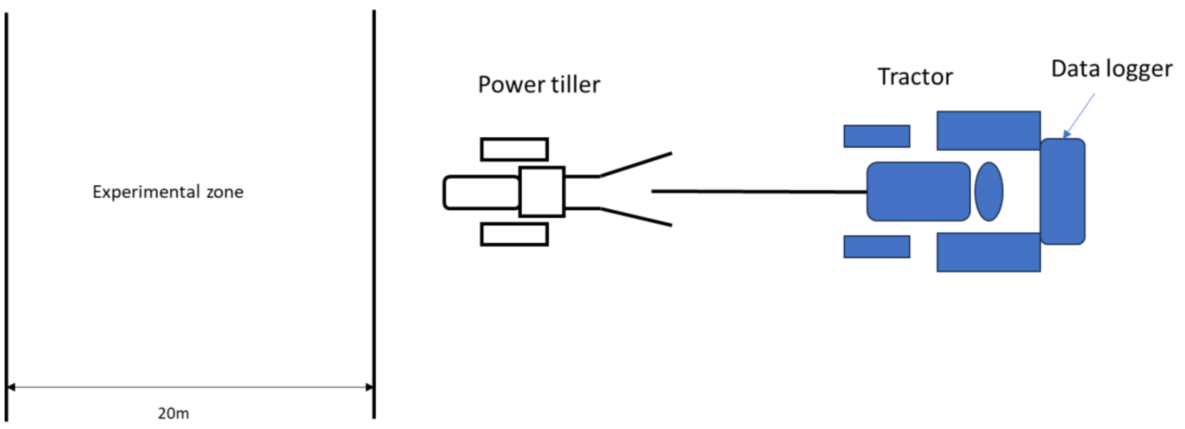

Figure 2: The power tiller attached to the tractor

Result and discussion.

Table 1 presents the outcomes of the drawbar pull force experiment conducted on the power tiller across two gear positions and various load levels. In the first gear position, the engine reached its maximum speed of 2540rpm, while the transmission peaked at 1350rpm, alongside an applied force of 60kgf. Contrastingly, under the second gear position with a load of 292kgf, the engine and transmission attained their lowest speeds of 2506rpm and 1318rpm, respectively. The power tiller achieved its highest travel speed of 0.212m/s with a load of 250kgf in first gear, whereas the lowest travel speed of 0.515m/s was observed with a load of 120kgf in second gear. Moreover, the maximum wheel slip percentage, reaching 38.61%, was observed at the power tiller's highest speed, while the minimum value of 1.96% was recorded in second gear with a load of 170kgf.

Table 1: The drawbar pull test

Gear Position	Drawbar pull (F)	Engine speed (Ne)	Transmission speed (Nt)	Time through 20m zone	Travelling speed (V)	Rolling Speed (βNt/60 XLt)	Wheel slip	Belt slip	Drawbar power
Unit	kgf	rpm	rpm	sec	m/s	m/s	%	%	PS
1	60	2540	1350	59.29	0.337	0.3483	3.16	1.575	0.2699
1	100	2525	1342	59.57	0.336	0.346236	3.76	1.577	0.4477
1	180	2530	1345	88.32	0.226	0.34701	34.87	1.552	0.5435
1	235	2532	1342	74.53	0.268	0.346236	22.54	1.849	0.8408
1	250	2531	1340	94.23	0.212	0.34572	38.61	1.956	0.7075
2	120	2519	1337	38.82	0.515	0.344946	3.37	0.044	0.8243
2	170	2525	1340	40.85	0.490	0.34572	1.96	0.057	1.1098
2	270	2518	1335	52.53	0.381	0.34443	23.4	0.1539	1.3706
2	292	2506	1318	60.36	0.331	0.340044	32.2	0.9533	1.2900

In Figure 5, a graphical representation showcases the correlation between drawbar power (y-axis) and drawbar pull force (x-axis). Displayed in both blue and red lines are the trends corresponding to the first and second gear settings of the power tiller. Both lines exhibit a positive slope, with the graph line representing the second gear position consistently positioned above that of the first gear. The peak performance of the second gear line is highlighted at a drawbar power of 1.3706PS, coupled with a drawbar pull force of 270kgf. Conversely, the first gear attains its maximum drawbar power, reaching 0.8408PS with a load of 235kgf.

CONCLUSION

The drawbar pull test was conducted on the two-wheel power tiller to measure its efficacy in delivering traction and pulling force across various load scenarios. The comprehensive analysis of the test outcomes furnishes crucial insights into the tractor's performance capabilities and potential applications within agricultural contexts. Highlighting the results of the drawbar pull test underscores the versatility of the two-wheel power tiller for various agricultural activities, such as soil preparation, ploughing, and cultivation. This comprehension of the tractor's capabilities facilitates informed decision-making regarding its optimal deployment in specific farming tasks. The discerned findings provide valuable guidance to farmers, manufacturers, and researchers, informing strategic choices concerning the utilization and enhancement of two-wheel power tillers in contemporary agricultural practices.

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