PERFORMANCE OF A 4-W TRACTOR IN THAILAND FIELD CONDITIONS

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ABSTRACT

Performance of a four- wheel tractor fabricated by Tongyang Moolsan Co., Ltd, Korea was tested in Thailand during May-June 2000. Wheel slip and field capacity were measured in three fields using different traction devices and implements. The tractor worked satisfactorily in the test conditions. Wheel slip of 26.05-33.63 % and the field capacity of 0.17 - 0.20 ha/hr were observed during plowing operation. Further tractive performance tests using a three-point linkage configuration are recommended in Thailand field conditions. Different designs of cage wheels are recommended to be tested to optimize the tractive performance.

Key word : Tractor, Paddy field, Slip, Field Capacity, Cage Wheel.

INTRODUCTION

Thailand is one of the major rice production countries in the world. The total area of Thailand is 51.31 million ha, of which 10.14 million ha is for rice field. The area for major crop is 9.19 million ha and the remaining 0.95 million ha is for second crop. Power sources used for plowing, puddling and levelling the soil in Thailand are animal (buffalo), 2- wheel walking type tractor and 4-wheel tractor. Land preparation methods in different areas vary depending on availability of machines, irrigation water, land shape and size and field conditions.

Walking type 2-W tractors are widely used because they are light weight, locally produced and low cost. In contrast, 4-W tractors are not popular due to their high cost and associated traction problems in paddy field conditions. Tractive performance of a 46.5 kW four wheel imported tractor, weighted 30 kN, was tested in Thailand in 1987. It was found that the tractor was immobilized due to wheel blocking with mud (Eam-o-pas et al. 1987). The tractor experienced 100 % slip with wheel sinkage of 30 cm. Limited research on the performance of 4-W tractors are observed. However, there are always demands for large 4-W tractors in the area where the field size is large and when a faster work rate is required. It is basically seen that small 4-W tractors can replace walking 2-W tractors if traction problems are minimized. Therefore, Tongyang Moolsan Co., Ltd has initiated a cooperative research with Kasetsart University, Thailand to conduct performance test of a tractor in Thailand paddy fields. A tractor was sent to Thailand in May 2000. Field test activities include test preparation, preliminary test, performance tests in farmer fields. This report provides details and results of performance tests conducted during May-June 2000 in Thailand.

PROCEDURES AND FILED TESTS

A tractor to be tested

A four-wheeled tractor fabricated by Tongyong Moolsan Co.,Ltd. Korea is sent to the Department of Agricultural Engineering, Kasetsart University , Thailand for tests. Specification of the tractor is shown in Table 1.

Paddy fields

Three farmer fields in the surrounding area of Kamphangsaen campus, Kasetsart university were located and used for field performance tests. In the tests, half of the field was used for slip and mobility tests and another half was used for field capacity tests.

Table 1. Tractor Specification

Model		TRX150
Dimensions	Overall Length(mm)	2800
	Overall Width(mm)	1300
	Overall Height(mm)	2050
	Wheel Base(mm)	1470
	Min. Ground Clearance(mm)	340
Weight(kg)		Approx. 1000
Engine	Maker	KUBOTA
	Model	D1105
	Gross Power(PS)	23
	Rated Speed(rpm)	2800
	Displacement(cc)	1123
	No. of Cylinders	3
Fuel Tank Capacity(Liters)		26
Tire Size	Front	6-14
	Rear	9.5-20
Drive Train	Clutch	Dry Type
	Transmission	Mechanical
	No. of Speeds(F/R)	F12/R12
	Differential Lock	Standard(Mechanical)
	Brakes	Wet Disc Type
Hydraulics	Pump Type	Gear Pump
	Implement Controls	Position
	Lift Capacity(kg)	900
	Steering Type	Hydrostatic Power steering
Rear PTO	Type	Continuous Live
	Speed(rpm)	540/1000
	Shaft Size(mm)	35

Field conditions
Before test, the field was flooded. Water level was approximately 10-20 cm. There were some grasses and vegetation on the surface before plowing . Amount of vegetation before the test depended on timing after harvesting. Field conditions were recorded and the soil properties were measured before each tests.

Test procedures
Field tests were performed in each fields using the tractor which was attached by a three-bottom disk plow and a raker for plowing and puddling operation respectively. Tests included slip measurement and field capacity. Wheel slip was measured in the field under the following conditions:

1. Wheel slip with rubber tires attachment
2. Wheel slip with rubber tires and cage wheels attachment
3. Wheel slip with rubber tires, cage wheels and disk plow attachment
4. Wheel slip with rubber tires, cage wheels and raker attachment

Before actual tests , tractor was operated using disk plow at different forward speeds. The speed that the operator was able to control the tractor comfortably was then selected. In the tests, gear no. 4 ,medium, was found to be appropriate. The engine revolution was set at 1,900 rpm. Forward speed of tractor on asphalt/concrete surface was measured. Then speed of the tractor under the conditions stated above were measured. Approximate slip was calculated. It should be noted that slip measurement using this method was an approximate estimation. The research team has planned to perform tractive performance tests using a three-point linkage configuration and to measure slip using proximity sensors or encoders to obtain more accurate results in the future tests.

Field capacity tests
Field capacity of the tractor for plowing and puddling/levelling operation were measured and reported in ha/hr. The rectangular shape field was selected. An aspect ratio of 2:1 was chosen. The field was flooded for 2-3 days before test period. First plowing was done using a disk plow. After first plowing puddling and leveling was peformed using a raker. Plowing operation using a headland pattern was performed. Time for turning on headland was recorded. Total time including headland finish-off was measured. Then, field capacity was calculated using total time and field size. For puddling operation using a raker, the tractor was operated using a headland pattern but puddling on headland was done continuously after each pass of the tractor along the length of the field.

Traction problems, wheel blocking, and stability of the tractor were also noted. After all tests were completed, feeling of the operator regarding position of control levers, steering system comfort, ease of operation, riding comfort , noise and vibration can be described.

RESULTS AND DISCUSSION

Tests in filed number 1

Before the test , tractor forward speed on concrete surface was measured (Gear M-4) at an engine rpm of 1900. Average forward speed was measured to be 1.1952 m/s (4.3027 km/hr). Forward speeds and wheel slip in the field were measured as shown in Table 2.

Table 2. Tractor forward speed in filed no. 1

Surface and tires/wheel attachment	Average tractor speeds (m/s)	Wheel slip (%)
1. Speed on concrete surface	1.1952	-
2. Speed in the field with rubber tires	0.9104	23.83
3. Speed in the field with rubber tires and cage wheel	0.9628	19.44

For field capacity tests, performance tests were performed using disk plow for first plowing operation in an area of 30 x 76 m^2. Plowing with a headland pattern was performed. A raker was used for puddling and levelling operation in the same area followed the first plowing operation. Results of filed capacity test in field number 1 are shown in Table 3.

Table 3 Results of field capacity tests in field no. 1.

Operation	Operation time/plowing time (hr)	Time for turning on headland (hr)	Field capacity (ha/hr)
Plowing using a disk plow	1.1356	0.2210	0.20
Puddling and levelling using a raker	0.4371	N.A.	0.52

Table 2 shows that wheel slip with rubber tires were 23.83 % and decreased to 19.44 % when cage wheels were attached. Field capacity of 0.20 ha/hr and 0.52 ha/hr were observed for plowing and puddling operation, respectively.

Tests in filed number 2

Forward speeds and wheel slip in field number 2 were measured as shown in Table 4. Field capacity tests was performed in an area of 25 x 50 m^2 . Results of field capacity tests in field number 2 are shown in Table 5.

Table 4. Tractor forward speed in filed no. 2

Surface and tires/wheel attachment	Average tractor speeds (m/s)	Wheel slip (%)
1. Speed on concrete surface	1.1952	-
2. Speed in the field with rubber tires	0.9489	20.64
3. Speed in the field with rubber tire sand cage wheel	0.9334	21.90
4. Speed in the field with rubber tires and cage wheel + disk plow	0.8838	26.05
5. Speed in the field with rubber tires and cage wheel + raker	1.0456	12.52

Table 5 Results of field capacity tests in field no. 2

Operation	Operation time/plowing time (hr)	Time for turning on headland (hr)	Field capacity (ha/hr)
Plowing using a disk plow	0.7287	0.2093	0.17
Puddling and levelling using a raker	0.2109	N.A.	0.59

Plowing operation in field number 2 resulted in a slip of 26.05 % and a field capacity of 0.17 ha/hr. Table 4 shows that wheel slip decreased to 12.52 % during puddling operation using a raker. This resulted in a higher field capacity of 0.59 ha/hr as shown in Table 5.

Tests in filed number 3

Forward speeds and wheel slip in field number 3 were measured as shown in Table 6. Field capacity tests for field number 3 were performed in an area of 20 x 48 m^2 . Results of filed capacity test in field no. 3 are shown in Table 7. A high slip of 33.63 % during plowing operation was observed. This resulted in a field capacity of 0.19 ha/hr.

Table 6. Tractor forward speed in filed no. 3

Surface and tires/wheel attachment	Average tractor speeds (m/s)	Wheel slip (%)
1. Speed on concrete surface	1.1952	-
2. Speed in the field with rubber tires	0.9595	19.72
3. Speed in the field with rubber tires and cage wheel	0.9288	22.29
4. Speed in the field with rubber tires and cage wheel + disk plow	0.7932	33.63
5. Speed in the field with rubber tires and cage wheel + raker	0.9109	23.79

Table 7 Results of field capacity tests in field no. 3

Operation	Operation time/plowing time (hr)	Time for turning on headland (hr)	Field capacity (ha/hr)
Plowing using a disk plow	0.4833	0.1072	0.19
Puddling and levelling using a raker	0..2162	N.A.	0.44

Table 2, 4, and 6 shows that field slip with rubber tires attachment without implement ranged from 19.72 – 23.83 %. Highest field capacity of 0.20 ha/hr was observed under the test conditions in field number 1 using gear number 4-M at 1,900 engine rpm.

CONCLUSIONS

From the test results, it was found that the tractor worked satisfactorily in Thailand field conditions. However during the field tests, some problems were found as follows:

(1) Wheel blocking with mud if the field was not flooded before first plowing. Generally, farmers will flood the field 2-3 days before plowing operation, therefore, wheel blocking problem is less in plowing operation.
(2) Leaking of hydraulic oil at the vent plug underneath driver seat was observed.

Based on these problems, the following suggestions are made:

(1) Modification of cage wheel is needed. Thai–local cage wheels with different designs should be tested. It was observed the tested cage wheel lug was two small for Thailand field conditions.
(2) Double cage wheels may be needed for test in the future because in some area the hard pan may be deeper than 30 cm.
(3) Proper wheel ballasting and front wheel weight must be identified for different field conditions.
(4) Rubber tires may not be necessary when operating in wet conditions. They can be replaced with cage wheels and provision must be made to enable easy transportation on farm roads eg. using steel belt around the circumference of the cage wheels.
(5) Tractive performance tests using load cells attachment with a three-point linkage configuration need to be performed.
(6) Heat balance test should be performed in Thailand environmental conditions.

Based on the existing Thailand conditions, there is a demand for suitable four-wheel tractors to be used in paddy fields. The tractor manufactured by Tongyoung Moolsan Co., Ltd. proved to be a promising unit in Thailand market provided that suitable traction aids are further identified and the tractive performance is optimized to avoid traction problems in wet paddy field conditions.

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