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Development of the riding-type rice transplanter for unpuddled transplanting

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Introduction

Transplanter have been developed for rice seedling planting into puddled soils to alleviate labour shortages and reduce costs of rice establishment (Adhikari et al., 2006). Although tillage for rice establishment is significantly mechanized in Bangladesh, 16-18 % of total production costs are due to tillage and land leveling (BRRI, 2013). Development of a rice transplanter suitable for unpuddled transplanting under minimum tillage conditions could further minimize the land preparation cost which will be of interest to small-holder farmers. No significant work to date has been conducted in Bangladesh to develop a rice transplanter for minimum tillage unpuddled soil conditions. The following development study was conducted to modify and evaluate a riding-type, 6-row mechanical rice transplanter for unpuddled soil conditions.

Materials and Methods

A strip tillage mechanism was attached in front of and in line with the rotary picker for transplanting rice seedlings (Fig. 1). Fabrication was conducted according to a design made at the FMPHT Division, BRRI. Engine power available at a 3600 rpm was conveyed to the strip tillage rotary shaft with the arrangement of a belt-pulley, worm gearing, shaft-universal joint, involutes spline shaft and bevel gear resulting in a 450 rpm rotary blade speed. A lever-operated tensioning pulley was included into the belt drive to engage and disengage the power to the strip tillage shaft. A B-section V belt (38° groove angle) was used based on design power and rpm of the engine shaft pulley. A straight-face worm gear was designed to reduce main shaft speed to 450 rpm from a secondary shaft speed of 2250 rpm considering transmitted power 1.75 kW. The tine was designed to produce a 2 cm deep ×2 cm wide strip (Fig. 1). The modified rice transplanter was evaluated for transplanting seedlings in moisture-saturated and unpuddled soils produced under minimum tillage.

Results

The values of specific draft (Barger et al., 1978) varied from 1.4 to 2 N/cm² of furrow cross section area for sandy soils, 2 to 5 N/cm² for sandy or silt loam soil and 4 N/cm² for clay loam soils and declined with increased soil moisture content up to 11.7%. A 2.6 N/cm² force was thus assumed for torque calculation considering a soil specific draft of 4 N/cm² and 35% reduction for saturated condition. It was calculated that about 1.0 kW power is required to cut strips simultaneously across the width of the rice transplanter in operation. A double-groove pulley of 12.5cm diameter was attached to the engine shaft to replace the single-groove pulley and to share the engine power for strip tillage by transmission to the secondary shaft attached below the engine shaft. Centre-to-centre distance of the engine shaft and the secondary shaft is 33.0 cm. A pulley (20 cm diameter) was attached to the secondary shaft to reduce the engine rpm from 3600 to 2250. Diameter of the secondary shaft was critically designed to be 2.3 cm considering the combined twisting and bending moments. Input shaft of the worm gear was coupled with the secondary shaft because of equal speed of the worm and the secondary shaft. Tangential load acting on the gear was calculated as 1088 N and
design tangential load was calculated as 2007 N. The design load was more than the tangential load acting on the gear (1088 N). The design is also safe from the stand point of dynamic, static and wear load because of more loads compared to the tangential load. Design diameter of the worm shaft was 14.05 mm (taken 20 mm) considering resultant bending moment and equivalent twisting moment on the worm shaft.

Bevel gears were used to connect the 90 degree intersecting shafts to transmit main shaft power to the rotary shaft of the strip tillage tine. Equal bevel gear having equal teeth and equal pitch angle connected two shafts whose axes intersected at a right angle. Because of same teeth, pitch angle for pinion and gear is same of 45 degree. An involutes spline shaft was used in the developed transplanter in between bevel gear and main shaft with hub to slide along the shaft. Total length of the shaft is 23.3 cm along with 17.5 cm spline shaft and hub. Transmitted torque of the spline shaft is same as the main shaft torque because of same rpm. Torque of the main shaft is 37.15 N-m based on transmitted load 1.75 Kw. The developed transplanter was tested in the FMPHD soil bin. During test, average strip size was 2.0 x 2.10 cm. Seedlings were placed uniformly in the strip without damage.

**Conclusion**

A commercial riding-type mechanical rice transplanter was modified to operate under minimum tillage unpuddled transplanting with the capability of making strips concurrently with rice transplanting, in a one pass operation following basic land preparation without puddling. The developed transplanter performed well in preliminary tests by making strips and by satisfactory seedling placement in unpuddled soil.

**References**


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