



Performance of *aus* rice in different tillage systems and crop establishment method in Southwest Bangladesh

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ABSTRACT

High labor wage and irrigation water scarcity are the major constraints to becoming rice production less profitable and unsustainable in Bangladesh. To address these problems, rice production needed less water and less labor consuming production technologies. In traditional rice production systems which is puddled-transplanted rice (PTR), a significant amount of water and labor are used for tillage (wet) and transplanting operations. A farmers' participatory on-farm trial was conducted to evaluate the performance of *aus* rice at different tillage systems and crop establishment methods in the southern part of Bangladesh. Wet tillage (puddled systems) to dry-tillage and transplanted rice to direct dry-seeded rice (DSR) may have the potential to reduce production cost by using less labor and water, resulting in higher profit. The trial examined tillage systems (strip tillage, reduced tillage and puddling) and crop establishment methods (direct dry-seeded and transplanted) in six farmers' fields in *aus* 2015. Crop established by reduced- and strip-tillage in DSR conditions reduced crop duration by 7 days compared to PTR. Grain yield (4.4-4.6 t ha⁻¹) was similar in DSR which is established by reduced- and strip-tillage conditions and PTR; however, total production cost in DSR was 15-18% lower than the PTR. Slightly higher but significantly similar gross income was recorded in PTR than DSR, however, net profit was significantly lower in PTR and it was due to higher production cost involvement. DSR has the potentiality of similar yield to PTR and reduces production cost which increases the net profit of rice production.

KEYWORDS: Agricultural mechanization, dry-seeded rice, strip-tillage, reduced-tillage, *aus* rice.

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INTRODUCTION

Rising costs of labor, high water, and energy required for puddled transplanted rice coupled with labor scarcity during the peak period of activity are the compelling factors to seek an alternate rice production method. Direct seeding of rice is an alternative to transplanted rice that could reduce the labor requirements for crop establishment and the demand for irrigation water [1, 2]. Direct seeded rice can be established either dry-seeded or wet-seeded, however, dry-seeding is becoming popular among the farmers of many Asian countries because of this systems is conducive to mechanization [3, 4]. In this systems, the crop can be established either zero tillage or strip tillage or full dry tillage (conventional) which support the principle of conservation agriculture (CA). The CA practices are now well established in different developed countries; however, not to popularize in Bangladesh yet.

Cropping systems of Bangladesh is highly intensified especially in the south-west and North-west part of the country where rice (*aman*) is the main crop in the wet season and a number of non-rice (*rabi*) or rice (*boro*) crops in the dry season [2, 5].

Bangladesh agriculture is predominant in rice-based and *boro* is the major rice crops due to higher yield potentiality and less risky compared to wet-season rice (*aman*) [6]. Last few years *boro* areas of some regions especially High-Ganges River Floodplains (south-west) and Barind Tracts (North-west) are decreasing because of water and labor scarcity. In these areas, diversifying cropping and production systems with low water-demanding crops is needed during *boro* [7]. For example, replacing *boro* rice with less water-demanding crops would save groundwater, but could reduce the total volume of rice production. A shortage of total rice production could be minimized by increasing the areas of *aus*. In south-west Bangladesh where Maize is the dominant crop in *rabi* and farmers commonly practice *aus* rice-Maize sequence there but *aus* rice is mostly transplanted. We assumed that the practice of direct dry-seeded rice instead of puddled-transplanted rice, crop establishment not only reduce the water use in rice farming but also reduces the production cost and increases the profitability. Therefore, the on-farm trial was conducted to evaluate the performance of *aus* rice at different tillage systems and crop establishment methods in the southern part of Bangladesh.

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MATERIALS AND METHODS

Experimental Sites and Seasons

On-farm trials were conducted during *aus* 2015 at Borai Village in Jhenaidah Sadar Upazila of Jhenaidah District, and Subdia Village in Chuadanga Sadara Upazila of Chuadanga District in Bangladesh. The experimental sites belong to the agro-ecological zone number 11 known as the High Ganges River Floodplain, a region of relatively high land not subject to flooding. The climate of the area is subtropical, with average annual rainfall of 1450 mm, 90% of which falls from June to October. The temperature during the *aus* season is favorable for rice production, with mean monthly minimum and maximum temperatures of around 25 and 35°C, respectively. The soils of the experimental fields at 0–15-cm depth were sandy loam in texture, with a bulk density of 1.56–1.61 Mg m⁻³, pH of 7.55–7.82. Rice was grown with partial irrigation in the pre-monsoon season (April–July) is known as the *aus* rice. The experimental site had the history of Maize-Transplanted *Aus*- short time vegetables or fallow cropping systems.

Experimental Design And Treatments

The study was conducted in six farmers' fields in a randomized complete block design.

Puddled Transplanted Rice (PTR)

Transplanting of 20-25 days old seedlings from the nursery into the puddled field. Two to three seedlings per hill were transplanted manually on the puddled soil. The line to line distance was 20 cm but the hill to hill was random.

Reduce Tillage Dsr (RT-DSR)

Reduce tillage was done a power tiller with a seedbox and sowing tynes attached, enabling tillage and sowing in a single pass; the whole soil surface is tilled to a depth of 2-4 cm; tillage did under dry to moist soil conditions; powered by a 2-wheel tractor.

Strip Tillage DSR (ST-DSR)

Strip tillage was done as for conventional tillage, except that all the tynes are removed from the tiller except for those immediately in front of the sowing tynes; only a narrow strip of the soil surface, about 3-5 cm wide, is tilled to a depth of 2-4 cm.

Land Preparation, Crop Establishment, and Management

Selected each field was divided into three equal plots and two plots were used for DSR (RT-DSR and ST-DSR) and one for PTR.

DSR

A non-selective herbicide glyphosate (Round up 3 l ha⁻¹) was sprayed one week before sowing RT-DSR and ST-DSR to kill the weeds. DSR crop was sown using certified seeds of high-yielding cultivars BRRI dhan48 (110d duration). Fertilizer except urea was applied immediately before sowing for DSR at the rate of

20, 45, 12, and 1.5 kg ha⁻¹ of P, K, S, and Zn in the forms of triple superphosphate (TSP), muriate of potash (MoP), gypsum, and zinc sulphate, respectively. Nitrogen in the form of urea was applied at the rate of 110 kg ha⁻¹ in four splits [20% at 14 days after sowing (DAS), 30% at 28-32 DAS, 30% at 45 DAS, and 20% at 60-65 DAS]. A power tiller seed drill (2BG-6A model, China) was used to plant dry rice seeds at a row spacing of 20 cm and seed rate of 45 kg ha⁻¹. The field was irrigated immediately after sowing and thereafter irrigation was based on when hair line crack appeared in the field. At each irrigation time, water was applied until its height on the soil surface reached 2-3 cm. Plots were kept weed-free by applying the pre-emergence herbicide pendimethalin at 1000 g ai ha⁻¹ at 2 DAS followed by two hands weeding at 20-25 and 40-45 DAS, respectively. The herbicide was applied at 450 L solution ha⁻¹ using a knapsack-sprayer with a boom with three flat-fan nozzles.

PTR

Land preparation in PTR plots was done with 2-3 passes by a power tiller followed by laddering prior to transplanting. Fertilizer except urea was applied before final land preparation at the same rate used for DSR. Seedlings were raised in a nursery bed following improved methods recommended by BRRI (BRRI, 2013). Twenty to twenty-five days old seedlings were used for transplanting with two to three seedlings per hill at a row spacing of 20 cm but the plant to plant was random (common practices by farmers). After transplanting standing water was always kept in the plots by applying 5-cm water at each irrigation which continued until the hard dough stage. Nitrogen fertilizer was applied at the rate of 110 kg ha⁻¹ in three splits [30% at 7-10 days after transplanting (DAT), 40% at 25-28 DAT, and 30% at 40-45 DAT]. Two manual weeding was done at 15-20 and 40-45 DAT, respectively.

Observations

Rice plant density was determined 15 DAS by counting the number of plants in four randomly selected 1 m lengths of a row in each subplot. The date of 50% anthesis was determined by daily counts of the number of panicles. The date of physiological maturity (PM) was the date when about 80% of the grains had turned a yellow-golden colour. The crop was harvested when most of the leaves had senesced.

Rice grain yield was determined by harvesting a 3 m x 2 m area (2 spots) in the center of each treatment plot. Grain yield was converted to t ha⁻¹ at 14% moisture content.

The number of irrigation and labor for weeding in different treatment plots was recorded.

Economic Analysis

Economic analysis was done as per the standard methods [18,19].

Statistical Analysis

Data were analyzed using ANOVA to evaluate differences between treatments, and the means were separated using least

significant differences (LSD) at the 5% level of significance (Crop Stat 7.2; International Rice Research Institute, Philippines).

RESULTS AND DISCUSSIONS

Crop Duration

Crop duration significantly affected by tillage systems and crop establishment methods (Figure 1). The highest duration (116 days) required for the crop establishment method PTR. DSR established by reduced and strip-tillage had significantly lower crop duration (7 days) than PTR. In DSR condition, crop duration reduced by 3-14 days was reported from many previous studies [1,2]. The main reason for the reduce crop duration in DSR condition than PTR condition is lack of transplanting shock which rice seedling usually face in transplanted condition. Rice usually take 5-10 days to overcome the transplanting shocked when transplant from nursery bed to the main field.

Grain Yield

The highest grain yield (4.6 t/ha) was recorded from the crop establishment method of PTR. Slightly lower but significantly similar grain yield was recorded from the reduced and strip tillage DSR (Figure 2). From many previous studies, it is found that yield of DSR and PTR almost similar if managed well [8,9] lower yield was also recorded from many previous studies where weeds were not managed well [10,11]. Some studies in DSR reported higher yield in strip tillage condition than reduced tillage where weed pressure was very low [2]. However, under high weed pressure situation, reduced tillage recorded higher yield than the strip tillage [12,13].

Economics

Production cost was significantly affected by crop establishment method (Figure 3). The highest production cost was involved with the PTR which was 15-18% higher than the DSR. The higher production cost in PTR than DSR was mainly due to land preparation, transplanting and higher irrigation cost in PTR than DSR. Weed management cost for DSR was higher than the PTR (data not presented). It was reported from the many previous studies that production cost of DSR is lower than the PTR [14-17]. The production cost of reduced and strip tillage was similar in our study which supports the findings of Alam *et al.* [1] in similar types of environment. Slightly higher gross income was recorded from the PTR method; however, it was significantly similar to DSR method (Figure 4). Slightly higher gross income in PTR was related to slightly higher grain and straw yield. The net profit was highest for strip tillage DSR (Figure 5). Compared with the strip-tillage DSR, reduced tillage DSR had slightly lower but significantly similar net profit. Net income of PTR was significantly lower than both strip and reduced tillage DSR. Although in DSR had slightly lower gross income than PTR; however, net profit in PTR was lower due to higher production cost involvement.

CONCLUSIONS

Both reduced and strip tillage have the potentiality to reduce production cost, resulting in higher net profit and appears to

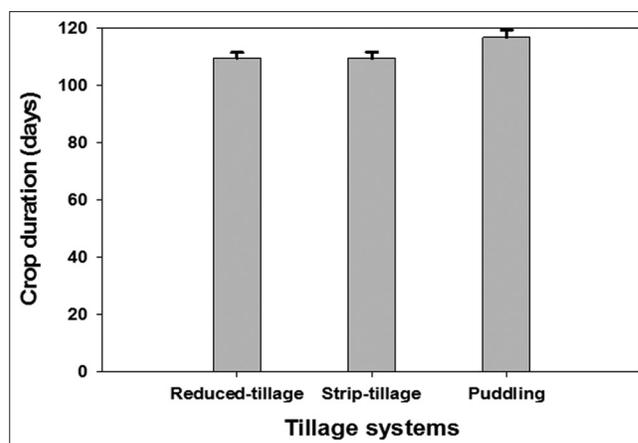


Figure 1: Effect of different tillage systems and crop establishment methods o crop duration

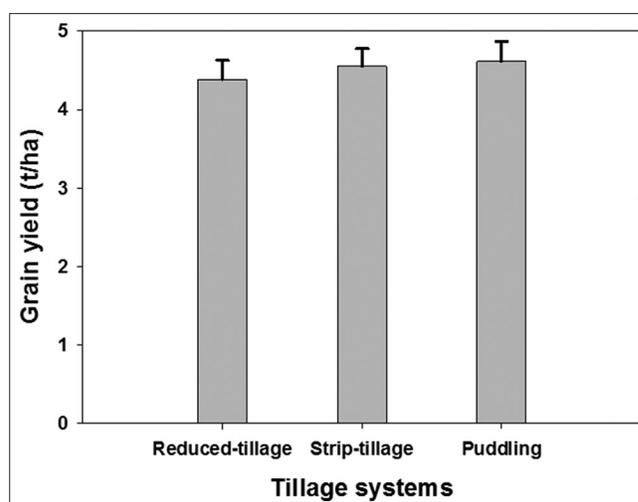


Figure 2: Effect of different tillage systems and crop establishment methods on grain yield

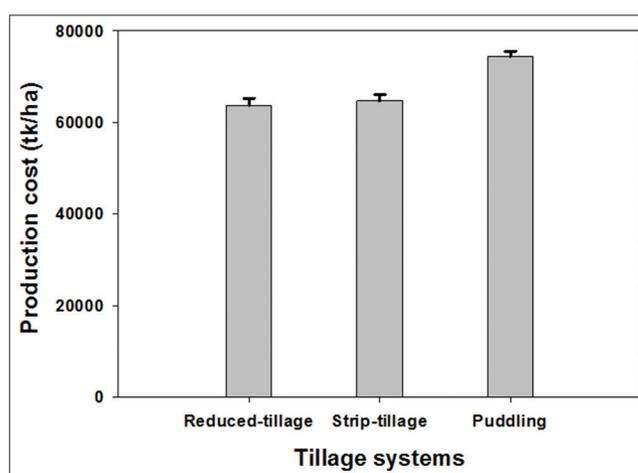


Figure 3: Effect of different tillage systems and crop establishment methods on total production cost

be a viable alternative to overcome the problem of labor and water shortage. If properly managed, comparable yield may

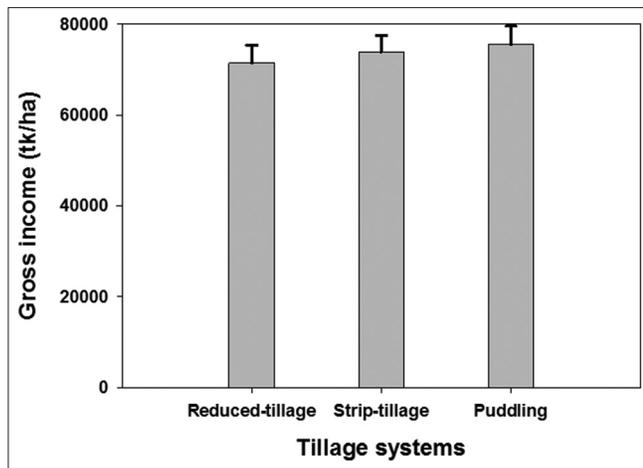


Figure 4: Gross income (taka ha⁻¹) in different crop establishment methods

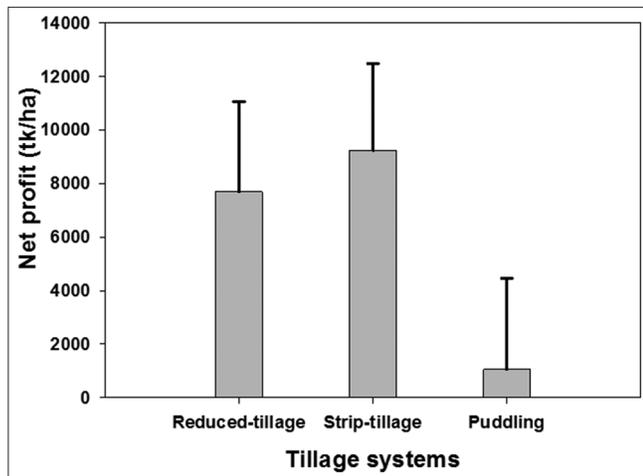


Figure 5: Net income (taka ha⁻¹) in different crop establishment methods

be obtained DSR compared with the PTR. If not managed efficiently, weeds may cause partial to complete failure of DSR crops. Therefore, farmers' participatory on-farm evaluation of DSR should be undertaken at the different agro-ecological zones (AEZs) in Bangladesh; this should include rigorous determination of crop yields, gross margin, irrigation input, and farmer perceptions. Government programs to promote adoption of DSR systems are needed which may help to increase cropping intensity; this should include capacity building of farmers and the agricultural machinery sector.

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