Increasing Productivity of Rice-Rice Cropping System Adopting Short Duration Rice and Mustard and Relay Cropping

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Abstract—The most dominant cropping pattern, t. aman (wet season rice)-fallow-boro (dry season rice) needs intensification for increasing system productivity and increase income of the Bangladeshi farmers. Two cropping patterns with the inclusion of mustard (Brassica campestris) in double rice, rice-tilled mustard-rice and rice-relay mustard-rice were compared in six farmers plot at Dumuria upazila of Khulna district in Bangladesh. The inclusion of mustard in between two rice increases the rice equivalent yield (REY) of 21 and 28% with relay and tilled mustard, respectively. The gross return was increased by 60% and 63% in rice-tilled mustard-rice and rice-relay mustard-rice cropping sequences compared to existing rice-rice cropping pattern. Experimental evidence reveals that there is an ample scope of substantial improvement of the productivity of the double rice cropping sequence with the inclusion of high yielding mustard varieties either by tilling the land or following relay cropping.

Keywords—Adoption mustard, rice-rice cropping system, system productivity.

I. INTRODUCTION

This Rice is the staple food for more than half of the world’s population. About 90% of the world’s rice is grown and produced (142 million ha area with production 622 million tons) in Asia [1]. As in many other countries of Asia, rice is the staple food and the economy mainly depends on rice production in Bangladesh. In terms of total rice production, Bangladesh now occupies the 4th position in the world. About 46,905,000 t of rice were produced on 11,741,000 ha of land in 2008, with a productivity of 3.99 t ha$^{-1}$ [1]. Bangladesh is now essentially self-sufficient in rice, its basic cereal [2]. In the self sufficiency of rice, the dominating cropping pattern t. aman (wet season rice) – fallow-boro (dry season rice) plays an important role which covers about 1.8 million hectare (about 22% of the total land) of land [3]. The late harvest of medium duration t. aman rice and increased cultivation of boro rice under this cropping pattern causes the decline of mustard area. The area under rapeseed and mustard is 0.30 million hectares which is about 80% of the total oilseed area [4]. Though the production of edible oil is being decreased, the demand is increasing day by day with the increasing population. The present domestic edible oilseed production is 267 thousand tons which meets only one third of national demand [5]. The present per capita oil consumption is only 10 g day$^{-1}$ as compared to the total need of 22 g day$^{-1}$ [6]. To fulfill the shortage of edible oil Bangladesh has to import a large quantity of edible oil every year. The Bangladesh Rice Research Institute (BRRI) has recommended the T. Aman-Mustard-Boro cropping pattern for the irrigated ecosystem [7, 8] with the inclusion of 65-70 days mustard variety, Tori7 in the transition period between t. aman and boro to address the issue. But the farmers harvest poor yield from Tori7 that can be increased manifold by introducing high yielding varieties [9, 10]. Recently, Bangladesh Agricultural Research Institute developed high yielding yellow seeded mustard (Brassica campestris) varieties, BARI sarisha14 and BARI sarisha15 which yield potential is higher than Tori7 and recommended for t. aman-mustard-boro cropping sequence [11]. Inclusion of these new varieties with growth duration of 80-85 days in between existing medium duration t.aman rice (145-150 days) and boro rice causes delay transplanting of boro and results decreased yield. Higher grain yield of boro rice are obtained when transplanting is carried out no later than 25 January, after which date the grain yield declines significantly [12, 13]. The cultivation of short duration aman rice can create opportunity to fit the new varieties of mustard in the t. Aman-fallow-boro cropping sequence. The varieties of such characteristics are recommended [14, 15] are BRRI dhan33, BRRI dhan39 and BINA dhan7. The relay cropping of mustard in moist soil on 7-10 days before of t. aman harvest may create opportunity to reduce the cost of land preparation and timely planting mustard and boro. In many of the cases, aman rice land of south western part of Bangladesh remains moist before harvest as the soils are clay loam to clay textured. Therefore, the present study was to evaluate the system productivity of t. aman-boro-fallow cropping system in the south western part of Bangladesh through farmers’ participatory approach.

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II. MATERIALS AND METHODS

A. Study site and season

The field study was conducted during 2011–2012 and 2006–2007 in farmers’ fields at Baratia and Rajapur village in Dumuria Upazila under Khulna district (22°43’N- 22°49’N and 88°19’-88°20’E) in Bangladesh. The area belongs to the agro-ecological zone of Ganges Tidal Flood Plain (AEZ13). The climate of the area is subtropical, with an average annual rainfall of 1710 mm with a peak in July and August, minimum mean temperature of 12.5 °C in January, and maximum mean temperature of 35.5 °C in Aril and May. The soils of the study fields at 0–15-cm depth were clay loam in texture, with a pH of 8.00–8.50, electrical conductivity of 0.6-2.4 dS m⁻¹, organic matter of 1.11-2.43 %, total N of 0.06-0.14% available P of 1.85-12.49 mg kg⁻¹, exchangeable K of 0.26–0.51 meq 100 g⁻¹, available S of 22.62–69.21 mg kg⁻¹, and Zn of 0.30–0.91 mg kg⁻¹, B of 0.11-0.68 mg kg⁻¹. Rice was grown on puddled soils with rain water in wet season (July–November) in 2011, that is, in the aman season as aman rice, and with irrigated conditions in the dry season during 2011–2012 (November–April), that is, in the boro season as boro rice. Mustard was grown in between two rices during November to January either in tilled condition or as relay with aman rice.

B. Technological option for validation

Three cropping sequence options were validated by the community. These were –i) short duration transplanted aman-tilled mustard-transplanted boro, ii) short duration transplanted aman-relay mustard-transplanted boro, iii) medium duration transplanted aman-transplanted boro (existing). The proposed options were shared with the farmers groups in the study area. A meeting with the farmer group was held at to share with the community about the technology and their requirement. Then the farmers opted for validating the proposed option(s) with their existing cropping sequence in six farmers’ plot. The medium duration aman variety, BR10 and the short duration varieties, BRRI dhan39 and BINA dhan7 were used in aman season. BRRI dhan28, the short duration varieties, BRRI dhan39 and BINA dhan7 were used in aman season. BR10 and the short duration varieties, BRRI dhan39 and BINA dhan7 were used in aman season.

C. Validation of preferred options

The farmers of the existing group of 25 farmers were trained on improved rice and mustard production. Some of the trained farmers participated in the validation trial and others joined with them in evaluation of proposed options at different stages of crops. At maturity of each crop in the sequence a field day was arranged with the community of test village and neighboring villages for analyzing the validated option and measuring the cost and benefit for comparison with the existing system.

D. Scaling out of the technology

After completion of a cycle of the cropping sequence, a farmer meeting was arranged in each location. The participating farmers opined a few ways for disseminating the preferred option to other communities.

E. Measurement and analysis of system productivity

Grain or seed yield was taken from a 10 m² area in the centre of each plot and expressed as t ha⁻¹ at 14% moisture for rice. The seed yield of mustard was measured as properly sun dried condition. Productivity of different cropping systems was compared in terms of rice equivalent yield (REY). The REY was computed by converting the yield of mustard into Tk. (value) and then this value is converted into the yield of rice as follows:

\[ \text{REY} = \frac{\text{mustard yield (kg) x mustard price (Tk. kg}^{-1})}{\text{price of paddy (Tk. kg}^{-1})} \]

The statistical analysis of the REY was done using IRRISTAT Windows Version 4.1. Unless indicated otherwise, differences were considered significant only at P ≤ 0.05. Economic analysis was performed to determine the efficiency of different cropping sequence options. The amount of different input required per hectare was calculated and the cost of input for different option was estimated based on their local market price. Labor wage for different operations of crop cultivation was captured and included in the total variable cost. The farm gate price of paddy and mustard was used for calculating gross return. The gross margin per hectare for each cropping sequence option was calculated by deducting the total variable cost from the gross return.

III. RESULTS AND DISCUSSION

The grain yield of aman rice was higher (5.71 t ha⁻¹) in rice-rice cropping sequence which was due to varietal yield potential. The medium duration rice variety (BR10) was used in rice-rice cropping pattern while short duration variety was used in other cropping pattern. The grain yield of short duration rice, BRRI dhan39 and BINA dhan7 was similar. Mustard seed yield was higher in tilled mustard (1.11 t ha⁻¹) might be due to higher plant population. In relay mustard, seed yield was lower (0.90 t ha⁻¹) because of less plant population might be for constraints of moisture stress on the surface of the soil. Similar seed rate used in tilled and relay cropping may be not adequate for relay planting. Boro rice yielded similarly in all the cases (5.70-5.83 t ha⁻¹). The rice equivalent yield was differed significantly among the validated cropping patterns (Table 1). The highest REY was recorded in rice-tilled mustard-boro cropping pattern (14.78 t ha⁻¹) significantly followed by rice-relay mustard-relay cropping pattern (13.93 t ha⁻¹). The lowest REY was found in rice-rice cropping pattern (11.52 t ha⁻¹). The inclusion of mustard in between rice increased the REY of 21 and 28% for relay and tilled establishment of mustard, respectively. Total variable cost was recorded in rice-tilled mustard-boro cropping pattern (Tk. 132465 ha⁻¹) compared to rice-rice cropping pattern (Tk. 127437 ha⁻¹) due to additional input including pesticide for managing aphid and tilling cost for land preparation for mustard. Relay cropping decreased (9%) the total variable cost in rice-relay mustard-boro cropping pattern that was due to the saving from tilling the land (Table 2). Total gross return
was recorded higher in mustard included cropping pattern compared to rice-rice cropping pattern. The highest gross return was in rice-tilled mustard-rice (Tk. 278006) followed by rice-relay mustard-rice (Tk. 266008) which were 54 and 48% higher than double rice cropping sequence. The higher market price of mustard contributed to higher gross return of the mustard included cropping patterns. The highest gross margin was earned in rice-relay mustard-rice cropping pattern (Tk. 149544 ha⁻¹) which was 63% higher compared to existing rice—rice cropping pattern. The gross margin in rice-tilled mustard-rice was 60% higher than rice-rice cropping sequence (Table 2).

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