ISSN 0258-7122
Bangladesh J. Agril. Res. 37(3): 415-432, September 2012

IMPACT OF POWER TILLERS ON PROFITABILITY OF SOME CROPPING PATTERNS IN SOME SELECTED AREAS OF BANGLADESH

M. A. QUAYUM[1], AMIN MUHAMMAD ALI[2] AND M. A. SALAM[3]

Abstract

A study was conducted to examine the impact of power tillers (PTs) on profitability of Boro rice based cropping patterns in some selected areas of Bangladesh in 2003. Six major Boro rice based cropping patterns out of 23 patterns in the study areas were examined to estimate the profitability differences among the power tiller and draught animal using farms round the year. Analysis revealed that gross return of MV Boro-MV T. Aus- MV T. Aman pattern is 10.5% higher for PT users than that for draught animal power (DAP) users. The total variable cost is 16.2% lower for PT users than that for DAP users resulting the gross margin 158% higher for PT users. Gross returns of MV Boro-MV T. Aus-LV T. Aman, MV Boro-Fallow- MV T.Aman and MV Boro-MV T.Aman-Mustard, MV Boro-MV T. Aus-Fallow patterns are respectively, 9.7%, 8.1%, 23.4% and 35.3% higher for PT users than that for DAP users. The benefit cost analysis indicates that PT users obtain higher yield, higher gross return and higher BCR from MV Boro-Vegetables-MV T. Aman pattern than those of DAP users. Thus, among all six identified patterns, this pattern is more profitable for PT users. The production cost of all six patterns by PT users is substantially lower than those of DAP users. In general, these six patterns are also found to be more profitable when power tillers are used in place of animal power. Use of power tillers was observed to be associated with higher cropping intensity in the study areas.

Keywords: Cropping pattern, productivity, profitability, power tiller and draft power.

Introduction

Conventionally a pair of bullock is used for land preparation in Bangladesh. In the 1960s, power tillers (PT) were introduced from Japan and later on from China for land preparation due to shortage of draught animal power. In 1988, the government withdrew duties and sale taxes on power tillers. As a result, the number of power tillers increased and the farmers of Bangladesh are cultivating their land by power tiller. The area cultivated by power tiller is increasing with the increase of power tiller. The proportion of area cultivated by PT is about 70% of the total cultivated land and the estimated number of power tillers was 194460

[1&3]Scenior Scientific Officer and Scientific Officer, Agricultural Economics Division, respectively, Bangladesh Rice Research Institute (BRRI), Gazipur-1701, [2]Professor, Department of Economics, Jahangirnagar University, Savar, Dhaka, Bangladesh.

in 2006 (Quayum, 2009). The latest Livestock Census quoted the number of working animals as 11.2 million (BBS, 1996). There are many advantages of PTs over bullock power for land preparation. Draught animal power requires 147 hours and a PT requires only 22 hours for tilling one hectare of land saving 125 hours (Quayum, 2003).

In Bangladesh, modern Boro rice is grown in 95 percent of the total Boro rice area, while in the Aus and Aman seasons MV rice is planted in 50 and 59 percent area of the total area used for growing Aus and Aman rice, respectively (MoA, 2007). Boro rice is the most important crop grown widely and about 80% of the land under Boro rice are prepared by power tiller. This is why Boro rice based cropping patterns are considered. In an earlier study, Elahi *et al.* (1999) found 10 rice based cropping patterns out of which Boro-Fallow-Fallow, Boro-Fallow-T.Aman, and Boro-T.Aus-T.Aman patterns covered 16.1, 34.6, 3.8 percent of the total area in Bangladesh, respectively. Potato-Boro-Fallow-T.Aman is one of the important patterns among the major 10 cropping patterns as observed by Howlader and Huda (2006). This cropping pattern is also the most profitable as reported by Quayum *et al*. (2006). The effect of farm mechanization on productivity and income depend mainly on specific kinds and nature of machinery use. However, Nakajud (1972); Binswanger (1977; 1981) cited a few studies on mechanization in India, Pakistan, and Nepal and some of those reported about increase in yield due to switch off to power tillers, while others reported no yield difference, or lower yields as farms shifted to power tillers. Alam (1981) conducted a study in Bangladesh and found that the yield of rice did not increase due to the use of power tiller.

Gill (1983) made a comparative analysis of animal and mechanical farm power in Bangladesh. He reported that PTs cultivate land more thoroughly and this practice leads to higher yields. PTs can cultivate heavy, dry or otherwise difficult soils, facilitate early planting and complete the job faster and thus permit more timely planting which in turn leads to increased annual yields for individual crop. In another study, it was found that 71% farmers obtained more yield when power tillers were used while 29% of farmers reported no difference in yield under two different techniques of cultivation (BRRI, 1997). PTs were reported to have little impact on rice yields. The average yield of Boro rice under PTwas found to be higher than that under bullock power (Barton, 2000; Quayum *et al*., 2004). Dey (2006) found that the yield of Boro rice was 4.8% higher in land operated by PT than that in land operated by DAP in Mymensingh.

Mechanization increased cropping intensity in the studied areas of Bangladesh (Gill, 1981; Alam, 2000; Dey, 2006). Most of the researchers stated that cropping intensity increases under power tiller use but very few researchers assessed the extent of increase in cropping intensity. Cropping intensity was 14.3% higher in land tilled by PT than that by DAP (Quayum, 2003). Quayum

(2003) showed that 45% of farmers using power tillers practiced MV Boro-LV T. Aus-MV T. Aman rice pattern (three rice crops) and 20 % of DAP users practiced the same pattern. The first category of farmers accounted for 65% of land where MV Boro-LV Aus-MV Aman rice pattern was practiced while the remaining 35% of land where MV Boro-LV Aus-MV Aman pattern was practiced accounted for by the second category. He further showed that three MV rice crop of short duration varieties were grown by the farmers using PT but this practice was not possible with bullock power in the study area. Quayum *et al*. (2006) found that 13% of the farmers practiced MV Boro-MV T. Aus-MV T. Aman rice pattern in the study area of Bogra using PT.

Most of the studies revealed that the yield, net returns, profits, and BCR for growing Boro rice are higher for farms using PT than those farms using DAP. Some of the earlier studies revealed that the yield and returns were lower for PT user farms than those for DAP user farms. All the studies were done for Boro rice production in a particular area or environment with small number of samples. The studies failed to consider the impact of introduction of PT on other rice crops and crops other than rice. The impact on crop production round the year was not considered by earlier studies. The interrelationship between introduction of PT on the one hand and cropping pattern or cropping intensity on the other hand was not adequately examined by earlier studies. It is important to introduce new high value crop in the existing cropping patterns to raise value addition and to raise cropping intensity in order to increase crop production. In this study analyses have been done taking samples from different areas of Bangladesh to examine the impact of PT on yield, cost and returns, profits, cropping patterns and cropping intensity to generate more widely applicable conclusions.

Specific objectives of the study:

1. to find out the major Boro rice based cropping patterns practiced by using power tiller and draught animal power in the study areas;
2. to document the differences in cropping intensity between PT users and DAP users in the study areas; and
3. to estimate and compare the profitability of major Boro rice based cropping patterns between PT users and DAP users and derive some policy implications.

Research Methods

Sampling procedure and data collection

Based on the intensity of power tiller use four districts, namely Comilla, Bogra, Chuadanga, and Manikgonj were purposively taken under this study. Four upazila, namely Chandina, Nandigram, Chuadanga Sadar and Singair were randomly selected. Two villages under each upazila were randomly selected from

one agricultural block. Selected villages were Rushulpur and Lona of Chandina, Nandigram, and Chakalma of Nandigram, Shangkarchandra and Manikdihi of Chuadanga Sadar, and Luxmipur and Beguntahary of Singair. A sample frame was developed from the comprehensive farmers list of Department of Agriculture Extension (DAE) for each village. Sample farmers were stratified into four stratum by the help of DAE and key informant farmers of the respective village. Stratum were (i) PT owner farmers (those who both own and use PT), (ii) PT hirer- user farmers (those who hire and use PT), (iii) draught animal power owner farmers (those who both own and use DAP) and (iv) draught animal power hirer-user farmers (those who hire and use DAP). Farmers those used both power tiller and draught animal power in the same plot for land preparation were identified and not considered as sample. Excluding these farmers (both used PT and DAP), the total population size was 764. Stratified random sampling technique was followed for selecting sample farms proportionately (35%) from each stratum. Structured questionnaires were used for collecting data from the farmers of the developed stratum. Sample size was 267. Among those 180 were power tiller users (41 PT owners and 139 PT hirers) and 87 were bullock power users (58 DAP owners and 29 DAP hirers) shown in table 1. Survey was done during April 2003 to December 2003. Data on all crops grown in the particular plot round the year were collected.

All the exercises done in this study are considered for all locations taken together. PT owner-users and PT hirer-users (called PT users) as well as DAP owner-users and DAP hirer-users (called DAP users) are also taken together to analyze the data

Analytical techniques

Profitability analysis and method of benefit cost ratio estimation were used for analyzing the data.

Table 1. Distribution of sample farmers in the selected villages.

Location	PT owner-Users	PT hirer-users	PT users	DAP owner-users	DAP hirer-users	DAP users	Total
Chandina (Rashulpur & Lona), Comilla	7	33	40	8	5	13	53
Nandigram (Nandigram & Chakalma), Bogra	18	37	55	21	7	28	83
Chuadanga Sadar (Sangkarchandra & Manikdihi), Chuadanga	8	38	46	16	9	25	71
Singair (Luxmipur & Beguntahary), Manikgonj	8	31	39	13	8	21	60
All/total	41	139	180	58	29	87	267

Results and Discussion

Performance of power tiller and DAP users in different Boro rice based cropping patterns

There are 23 Boro rice based cropping patterns out of which 8 are negligible in terms of area covered in the study areas (Table 2). The 6 main cropping patterns out of 15 major cropping patterns were examined in this study. These patterns are (1) MV Boro-MV T. Aus- MVT. Aman, (2) MV Boro- MV T. Aus- LV T. Aman, (3) MV Boro- Fallow- MV T. Aman, (4) MV Boro- MV T. Aman-Mustard, (5) MV Boro-Vegetables- MV T. Aman and (6) MV Boro-MV T. Aus-Fallow.

About 32.2% farmers of the total farmers practiced MV Boro-MV T. Aus-MV T. Aman pattern covering 12.2% area of the total area under PT while 36.8% farmers practiced this pattern covering 10.2% area of the total area under DAP.

MV Boro-MV T.Aus- MVT.Aman cropping pattern

This pattern is practiced in Mymensingh, Sherpur, Netrokona, Comilla region, Chittagong, Noakhali, Laxmipur, Dhaka region, Jessore region, Rajshahi region (BRRI, 2002; BRRI, 2004). Average total yield of this pattern in areas considered in this study is 6.9% higher for PT users than that for DAP users (Table 3). The gross return of this pattern is obtained higher (10.5%) for PT users. The total variable cost of MV Boro-MV T. Aus- MV T. Aman pattern is16.2% lower for PT users than that for DAP users. The gross margin is found 158.1% higher for PT users than that for DAP users and the difference as gross margin is statistically significant. The total production cost of the pattern is found higher on full cost basis for DAP users but this cost is lower on cash cost basis for DAP users than that for PT users. However, the net returns on both full cost and cash cost basis are higher for PT users than that for DAP users. The respective benefit cost ratios were higher for PT users on full cost and variable cost basis. Thus this pattern is found to be more profitable on full cost and variable cost basis for PT users than for DAP users.

MV Boro- MV T. Aus- LV T. Aman cropping pattern

The total grain yield and gross return of MV Boro- MV T. Aus- LV T. Aman is found to be 3.2% and 9.7% higher for PT users than that for DAP users, respectively (Table 4). The production cost is higher for DAP users than that for PT users on both variable and full cost basis, but it was 3.4% higher on cash cost basis for PT users. The gross margin and net returns of this pattern are found significantly higher for PT users compared to that for DAP users. The BCRs obtained for PT users are 30.3% and 25.3% higher on variable cost and full cost basis respectively than those for DAP users. On cash cost basis, this pattern is not profitable for PT users because higher amount of cash is spent by the PT users.

Table 2. Major Boro rice based cropping patterns found and their relative importance in the study areas.

Sl.no.	Major Cropping patterns	PT users		DAP users	
		% of farmers	% of area of the total cropped area	% of farmers	% of area of the total cropped area
1.	MV Boro- MV T. Aus- MV T.Aman	32.2	12.2	36.8	10.2
2	MV Boro-Fallow- MV T.Aman	19.4	22.0	17.2	23.1
3	MV Boro- MV T. Aus- LVT. Aman	4.5	6.5	5.8	7.5
4.	MV Boro- Fallow-Fallow	5.0	2.3	1.2	5.2
5.	MV Boro- Fallow-LV. Aman	2.2	2.5	0	0
6	Mustard-MV Boro- MV T.Aman	8.3	21.2	6.9	15.6
7.	Vegetables- MV Boro- MV T.Aman	5.0	20.4	8.0	16.0
8.	Potato -MV Boro-MV T. Aus-MV T.Aman	1.2	1.4	0	0
9.	Potato-MV Boro- MVT. Aus-LV T. Aman	0.6	0.3	0	0
10.	MV Boro- MVT. Aus-Fallow	11.1	7.5	3.4	8.4
11.	Potato -MV Boro-MV T.Aman	0.7	5.5	1.1	4.0
12	Til -MV Boro – MV T.Aman	2.8	1.6	4.6	2.3
13.	Potato -MV Boro- LV Aus	1.1	0.6	2.3	0.8
14.	MV Boro-Mug- MV T.Aman	1.1	1.2	4.6	1.9
15.	MV Boro- GM-MV T.Aman	0	0	4.6	1.1
16.	Other patterns (8)	4.7	2.9	4.5	4.2
Total		100.0	100.0	100.0	100.0

Source: Field survey, 2003; Differences in figures are due to rounding. Mustard and Potato are grown before Boro planting. GM means green manure.Other eight patterns are not shown due to less area coverage.

Table 3. Economic performance of cropping pattern MV Boro- MV T. Aus-MV T. Aman in the study areas, 2002-03.

(In thousand Tk.)

Items	PT				DAP				Difference (PT-DAP)
	MV Boro	MV T. Aman	MV T. Aus	Total	MV Boro	MV T. Aman	MV T. Aus	Total	
Main product									
Grain yield (t/ha)	4.8	3.6	3.4	11.9	4.4	3.3	3.3	11.1	0.8 (6.9)
Straw yield (t/ha)	4.3	3.2	3.0	10.5	3.7	2.8	2.8	9.3	1.2 (12.5)
A. Gross return (Tk./ha)	40.8	30.9	28.7	100.4	35.4	27.7	27.8	90.9	9.6 (10.5)
B. Total variable cost (Tk./ha)	27.9	18.2	18.4	64.5	30.1	22.8	24.0	77.0	-12.5 (-16.2)
C. Gross margin (A-B)	12.9	12.7	10.3	35.9	5.3	4.9	3.7	13.9	22.0 (158.1)
D. Total fixed cost (Tk./ha)	5.2	4.8	4.8	14.8	4.9	4.7	4.7	14.3	0.5 (3.3)
Total production cost (Tk./ha):									
E. Full cost basis	33.1	23.0	23.2	79.3	35.1	27.4	28.8	91.2	-12.0 (-13.1)
F. Cash cost basis	21.6	10.4	10.2	42.2	17.1	10.0	10.9	38.0	4.2 (11.0)
Net return (Tk/ha):									
G. Full cost basis (A-E)	7.7	7.9	5.5	21.2	0.4	0.3	-0.1	-0.4	21.5 (5884.1)
H. Cash cost basis (A-F)	19.3	20.5	18.5	58.2	18.3	17.7	16.8	52.9	5.4 (10.2)
Benefit cost ratio:									
Variable cost basis (A/B)	1.5	1.8	1.6	1.6	1.2	1.2	1.2	1.2	0.4 (32.2)
Full cost basis (A/E)	1.3	1.4	1.3	1.3	1.0	1.0	1.0	1.0	0.3 (27.0)
Cash cost basis (A/F)	2.0	3.1	3.0	2.4	2.2	3.2	2.7	2.4	-0.0 (-0.4)
No. of observations	58	58	58	58	32	32	32	32	-

Source: Field survey, 2003; Differences in figures are due to rounding.

* Figures in the parentheses indicate the percentages of the difference

Table 4. Economic Performance of cropping pattern, MV Boro-- MV T. Aus - LV T. Aman in the study areas, 2002-03.

(In thousand Tk.)

Items	PT				DAP				
	MV Boro	MV T. Aus	LV T. Aman	Total	MV Boro	MV T. Aus	LV T. Aman	Total	Difference (PT-DAP)
Main product									
Grain yield (t/ha)	4.6	3.3	2.5	10.5	4.6	3.0	2.5	10.2	0.3 (3.2)
Straw yield (t/ha)	3.9	2.6	2.4	9.0	3.7	2.5	2.3	8.5	0.4 (5.0)
A**. Gross return (Tk./ha**)	36.5	28.1	21.8	86.4	34.5	24.0	20.3	78.7	7.6 (9.7)
B. Total variable cost (Tk./ha)	24.9	17.0	14.0	55.8	28.0	20.3	18.2	66.4	-10.6 (-16.0)
C. Gross margin (A-B)	11.6	11.2	7.8	30.6	6.5	3.7	2.1	12.3	18.3 (148.1)
D. Total fixed cost (Tk./ha)	4.9	4.6	4.5	13.9	4.6	4.4	4.3	13.3	0.7 (5.0)
Total production cost (Tk./ha)									
E. Full cost basis	29.8	21.5	18.4	69.7	32.6	24.6	22.5	79.7	-10.0 (-12.6)
F. Cash cost basis	20.1	9.3	6.7	36.1	17.3	9.9	7.7	34.9	1.2 (3.4)
Net return (Tk./ha)									
G. Full cost basis (A-E)	6.7	6.6	3.4	16.7	1.9	-0.6	-2.2	-1.0	17.7 (1762.6)
H. Cash cost basis (A-F)	16.4	18.8	15.1	50.3	17.2	14.1	12.6	43.8	6.5 (14.7)
Benefit cost ratio									
Variable cost basis (A/B)	1.5	1.7	1.6	1.6	1.2	1.2	1.2	1.2	0.4 (30.3)
Full cost basis (A/E)	1.2	1.3	1.2	1.2	1.1	1.0	0.9	1.0	0.3 (25.3)
Cash cost basis (A/F)	1.9	3.1	3.4	1.7	2.0	2.7	3.1	2.3	-0.5 (-23.6)
No. of observations	8	8	8	8	5	5	5	5	-

Source: Field survey, 2003; Differences in figures are due to rounding
Figures in the parentheses indicate the percentages of the difference

MV Boro- Fallow- MV T. Aman cropping pattern

The economic performance of the cropping pattern MV Boro- Fallow- MV T. Aman which is the most important cropping pattern in terms of area coverage shown in Table 5. This pattern is found to be practiced in highland, medium highland, and medium lowland covering 22.2 percent area of the total area in Bangladesh and the average yield is 7.7 ton/ha/year (Khan *et al*., 2006). The total grain yield and gross return of this pattern are found to be 6.6% and 8.1% higher for PT users than those for DAP users. The production cost of this pattern is found higher for DAP users compared to that for PT users both on variable cost and full cost basis. Although the cash cost is higher for PT than that for DAP users, the net returns on cash cost basis is higher for PT users compared to that for DAP users. The gross margin and net returns of this pattern are found higher for PT users compared to that for DAP users. The estimated benefit cost ratio (BCR) was higher for PT users than those for DAP users on variable cost, full cost and cash cost basis. Thus the above discussions indicate that the MV Boro-Fallow-MV T. Aman pattern is more profitable when PT is used rather than DAP use for cultivation of land. In the patterns it is seen that in some cases the BCRs are found to be higher in production of MV T. Aus and MV T. Aman rice compared to MV Boro rice production due to high irrigation cost involvement in MV Boro rice production.

MV Boro- MV T. Aman-Mustard cropping pattern

The gross return of the pattern of MV Boro- MV T. Aman-Mustard is 23.4 percent higher for PT users compared to that for DAP users (Table 6). Variable cost and full cost are found to be higher for PT users. The total production cost is, more or less, same for both the groups on cash cost basis. The gross margin and net returns on full cost and cash cost basis are higher for PT users than those for DAP users. The BCR on variable cost, full cost and cash cost basis are found to be higher when PT is used rather than DAP to grow this pattern. Therefore, this pattern is found to be profitable for PT users. It may be noted that mustard is grown and harvested before MV Boro planting. After harvesting mustard crop MV Boro seedlings are transplanted. In this case land preparation cost is less for both the groups.

MV Boro-Vegetables- MV T. Aman rice cropping pattern:

The gross returns of MV Boro-Vegetables-MV T. Aman pattern is found to be 19.7 percent higher for PT users than that for DAP users (Table 7). The total variable cost and full cost are higher for DAP users. On cash cost basis, the production cost is more or less same for both the groups. The benefit cost analysis also indicates that PT users obtain higher BCR from MV Boro-Vegetables-MV T. Aman pattern than DAP users implying that this pattern is more profitable for PT users. Therefore, the yield, gross return, gross margin, net return and BCR of every cropping pattern is found to be higher for PTusers than those for DAP users.

Table 5. Economic performance of cropping pattern, MV Boro-Fallow –MV T.Aman in the study areas, 2002-03.

(In thousand Tk.)

Items	PT				DAP				Difference (PT-DAP)
	MV Boro	Fallow	MV T. Aman	Total	MV Boro	Fallow	MV T. Aman	Total	
Grain yield (t/ha)	4.7	-	3.8	8.5	4.4	-	3.6	8.0	0.5 (6.6)
Straw yield (t/ha)	4.3	-	3.6	7.9	4.1	-	3.4	7.5	0.4 (5.8)
A. **Gross return (Tk./ha)**	41.2	-	33.1	74.3	38.0	-	30.8	68.7	5.6 (8.1)
B. Total variable cost (Tk./ha)	33.6	-	19.6	53.3	35.9	-	24.7	60.6	-7.4 (-12.1)
C. Gross margin (A-B)	7.6	-	13.5	21.1	2.0	-	6.1	8.2	12.9 (158.9)
D. Total fixed cost (Tk./ha)	5.0	-	4.5	9.4	4.5	-	4.2	8.7	0.8 (8.6)
Total production cost (Tk./ha)									
E. Full cost basis	38.6	-	24.1	62.7	40.4	-	28.8	69.3	-6.6 (-9.5)
F. Cash cost basis	25.2	-	11.3	36.5	-22.6	-	11.6	34.2	2.3 (6.6)
Net return (Tk./ha)									
G. Full cost basis (A-E)	2.7	-	9.0	11.6	-2.5	-	1.9	-0.5	12.2 (2239.3)
H. Cash cost basis (A-F)	16.0	-	21.8	37.8	15.4	-	19.1	34.5	3.3 (9.6)
Benefit cost ratio									
Variable cost basis (A/B)	1.3	-	1.7	1.4	1.1	-	1.3	1.1	0.3 (23.9)
Full cost basis (A/E)	1.1	-	1.4	1.2	1.0	-	1.1	1.0	0.2 (20.2)
Cash cost basis (A/F)	1.7	-	3.1	2.0	1.8	-	2.9	2.0	0.0 (1.5)
No. of observations	35		35	35	15		15	15	-

Source: Field survey, 2003; Differences in figures are due to rounding

* Figures in the parentheses indicate the percentages of the difference

Table 6. Economic performance of cropping pattern MV Boro- MV T. Aman-Mustard in the study areas, 2002-03.

(In thousand Tk.)

Items	PT				DAP				*Difference (PT-DAP)
	MV Boro	MV T. Aman	Mustard	Total	MV Boro	MV T. Aman	Mustard	Total	
Main product									
Grain yield (t/ha)	5.1	3.6	1.4	-	4.9	3.6	1.2	-	-
By-product:									
Straw/stick yield (t/ha)	4.8	3.4	-	8.2	4.2	3.0	-	7.2	0.1 (13.8)
A**. Gross return**	44.9	30.1	29.0	104.0	39.5	29.4	25.4	84.3	19.7 (23.4)
B. Total variable cost	34.0	18.8	17.8	70.5	32.5	21.0	16.1	69.6	0.1 (1.4)
C. Gross margin (A-B)	11.0	11.3	11.2	33.5	7.0	8.4	9.3	24.7	8.8 (35.5)
D. Total fixed cost	5.3	4.6	4.6	14.6	4.5	4.1	4.0	12.5	2.1 (16.5)
Total production cost									
E. Full cost basis	39.3	23.4	22.4	85.1	36.9	25.1	20.1	82.1	3.0 (3.7)
F. Cash cost basis	29.0	9.7	7.9	46.6	24.1	12.7	9.6	46.4	0.2 (4.1)
Net return									
G. Full cost basis (A-E)	5.6	6.7	6.6	18.9	2.5	4.3	5.4	12.2	6.7 (55.0)
H. Cash cost basis (A-F)	16.0	20.4	21.0	57.4	15.3	16.7	15.8	47.9	9.6 (20.0)
Benefit cost ratio									
Variable cost basis (A/B)	1.4	1.7	1.6	1.5	1.3	1.5	1.6	1.2	0.3 (21.5)
Full cost basis (A/E)	1.2	1.3	1.3	1.2	1.1	1.2	1.3	1.0	0.2 (18.4)
Cash cost basis (A/F)	1.6	3.5	3.7	2.2	1.7	2.5	2.7	1.8	0.4 (22.5)
No. of observations	15	15	15	15	6	6	6	6	-

Source: Field survey, 2003. * Figures in the parentheses indicate the percentages of the differences

Table 7. Economic performance of cropping Pattern MV Boro- Vegetables-MV T. Aman in the study areas, 2002-03.

(In thousand Tk.)

Items	PT				DAP				Difference (PT-DAP)
	MV Boro	Vegetables	MV T. Aman	Total	MV Boro	Vegetables	MV T. Aman	Total	
Main product									
Grain yield (t/ha)	4.8	13.2	3.5	-	4.5	9.8	3.3	-	-
By-product:									
Straw yield (t/ha)	4.0	-	3.3	7.2	4.1	-	3.1	7.2	0.02 (0.20)
A**. Gross return**	42.2	100.1	29.7	172.1	38.9	76.8	28.1	143.7	28.33 (19.70)
B. Total variable cost	37.0	23.3	20.4	80.7	40.5	21.3	27.6	89.4	-8.62 (-10.67)
C. Gross margin (A-B)	5.2	76.8	9.3	91.3	-1.6	55.5	0.6	54.4	36.95 (67.93)
D. Total fixed cost	5.1	4.6	4.6	14.3	4.5	4.0	4.1	12.6	1.73 (13.73)
Total production cost									
E. Full cost basis	42.1	28.0	25.0	95.0	45.0	25.3	31.6	101.9	-6.89 (-7.25)
F. Cash cost basis	27.4	12.8	11.7	51.9	25.7	11.4	13.5	50.7	1.22 (2.40)
Net return									
G. Full cost basis (A-E)	0.2	72.2	4.8	77.1	-6.1	51.4	-3.5	41.8	35.22 (84.20)
H. Cash cost basis (A-F)	14.8	87.3	18.1	120.2	13.1	65.4	14.6	93.1	27.11 (29.13)
Benefit cost ratio									
Variable cost basis (A/B)	1.1	4.5	1.5	2.1	1.0	3.7	1.0	1.6	0.52 (32.30)
Full cost basis (A/E)	1.0	3.7	1.2	1.8	0.9	3.1	0.9	1.4	0.40 (28.36)
Cash cost basis (A/F)	1.6	7.9	2.6	3.3	1.5	6.9	2.1	1.5	1.78 (115.58)
No. of observations	9	9	9	9	7	7	7	7	-

Source: Field survey, 2003. * Figures in the parentheses indicate the percentages of the differences

Table 8. Economic performance of cropping pattern MV Boro- MV T. Aus-Fallow in the study areas, 2002-03.

(In thousand Tk.)

Items	PT				DAP				*Difference (PT-DAP)
	Boro	MV T. Aus	Fallow	Total	Boro	MV T. Aus	Fallow	Total	
Main product									
Grain yield (t/ha)	5.0	3.4	-	8.4	4.8	3.3	-	8.1	0.2 (3.0)
Straw yield (t/ha)	4.6	3.4	-	8.0	4.6	3.4	-	8.0	0.0 (0.2)
A**. Gross return (Tk./ha**)	47.8	28.5	-	74.3	45.5	28.2	-	73.7	0.7 (0.9)
B**. Total variable cost (Tk./ha)**	40.2	22.1	-	62.3	39.2	24.1	-	63.3	-1.0 (-1.6)
C. Gross margin (A-B)	7.6	6.4	-	14.0	6.3	4.1	-	10.4	3.7 (35.3)
D. Total fixed cost (Tk./ha)	4.7	4.6	-	9.3	4.3	4.6	-	8.9	0.5 (5.3)
Total production cost (Tk./ha)									
E. Full cost basis	44.9	26.7	-	71.6	43.2	28.7	-	72.2	-0.5 (-0.7)
F. Cash cost basis	28.9	16.7	-	45.7	25.4	18.2	-	43.6	2.1 (4.8)
Net return (Tk./ha)									
G. Full cost basis (A-E)	2.9	1.8	-	4.7	2.0	-0.5	-	1.5	3.2 (2.1)
H. Cash cost basis (A-F)	18.9	11.8	-	30.7	20.1	10.0	-	30.1	0.6 (1.9)
Benefit cost ratio									
Variable cost basis (A/B)	1.2	1.3	-	1.2	1.2	1.2	-	1.2	0.1 (6.0)
Full cost basis (A/E)	1.1	1.1	-	1.1	1.0	1.0	-	1.0	0.1 (6.0)
Cash cost basis (A/F)	1.7	1.7	-	1.7	1.8	1.6	-	1.7	0.0 (0.6)
No. of observations	20	20		20	3	3		3	-

Source: Field survey, 2003; Differences in figures are due to rounding.

* Figures in the parentheses indicate the percentages of the differences

Table 9. Area devotion for different cropping practices and cropping intensity under PT and DAP use in the study areas.

Methods	Single cropped area (ha)	Double cropped area (ha)	Triple cropped area (ha)	Quadruple cropped area (ha)	Net cropped area (ha)	Total cropped area (ha)	Cropping intensity (%)
PT	2.4 (10.6)	5.8 (25.6)	14.0 (61.8)	0.4 (1.9)	22.8 (100.0)	58.0	254.6
DAP	1.1 (11.5)	2.4 (26.0)	5.7 (61.7)	0.1 (0.9)	9.2 (100.0)	22.7	247.8
All	3.5 (10.9)	8.2 (25.7)	19.7 (61.8)	0.5 (1.6)	31.9 (100.0)	81.0	254.2
National*	2843.79 (35.5)	3974.91 (51.0)	978.15 (13.5)	0.0	7796.84 (100.0)	13728.04	179.0

Source: Field survey, 2003; Figures in the parentheses indicate percentage of the total net cropped area.* National figures are in thousand hectares in 2006-07 (BBS, 2009). Differences in figures are due to rounding. Figures are the total value of the four locations.

MV Boro-MV T. Aus-Fallow cropping pattern

The yield and gross return of MV Boro-MV T. Aus-Fallow cropping pattern is higher for the farms using PT compared to the farms using DAP (Table 8). Production cost on variable cost and full cost basis are found to be higher in farms using DAP. The gross margin, net returns, and BCR are higher in PT using farms. Thus this pattern is more profitable for PT users compared to the DAP users.

Impact of power tillers on cropping intensity

Impact of PT on cropping intensity has been discussed in this section. For PT users the proportion of single cropped, double cropped, triple cropped and quadruple cropped areas to total net cropped area are found to be 10.6%, 25.6%, 61.8% and 1.9%, respectively, while under DAP users, the corresponding figures are found to be 11.5%, 26.0%, 61.7% and 0.9%, respectively (Table 9). Cropping intensity achieved by PT users spread over all locations is about 255% and that for DAP users is about 248 % in the study area. The average cropping intensity is about 254% in the study area. The national average cropping intensity was nearly 179% in 2007-08 (BBS, 2009).

Cropping intensity depends mainly on level of land, moisture content of the soil and availability of irrigation facilities especially in dry season. Using power tillers land preparation can be done faster. This may help growing more crops in a plot other things remaining the same. Power tiller users are more likely to grow high value, high input-crop like potatoes or vegetables or mustard. This study also supports this. Farmers those used PT could plant their crops significantly earlier than animal power users do and reduce costs by dispensing with manual labour for breaking clods behind animal ploughing. Therefore, in this study it is found that there is also an impact of using PT on cropping intensity.

Conclusion

The yield of MV Boro, MV T. Aman rice, and vegetables are found to be higher when PT is used for land preparation and the differences of yield of these crops between PT users and DAP users are found to be important. The total variable cost for MV Boro rice is about 32% higher when DAP is used in place of PT. Therefore, MV Boro rice cultivation is substantially more profitable for PT users than that for DAP users on variable cost basis. Similar result is found for total cost of production on full cost basis. The findings indicate that PT users earn sufficiently higher return compared to DAP users for MV T. Aman rice cultivation on full cost, cash cost and variable cost basis. Similar results are found in case of LV T. Aman and MV T. Aus rice as well as vegetables, mustard and potato. The cost- return analysis also indicates that PT use reduces cost and

is associated with higher yield, higher return, higher net return and higher benefit cost ratio in most of the locations for most of rice and non-rice crops.

Out of 15 major prevailing cropping patterns in Bangladesh, six main cropping patterns have been analyzed. The profitability analysis indicates that MV Boro-MV T. Aus- MV T. Aman and MV Boro-MV T. Aus-LV T. Aman patterns are found to be more profitable when PT is used both on full cost and variable cost basis. Adoption of MV Boro-Fallow- MV T. Aman pattern using PT was found more profitable on full cost, cash cost, and variable cost basis. Similar results were obtained in case of MV Boro-MV T. Aus-Mustard, MV Boro- Vegetables-MV T. Aman and MV Boro-MV T. Aus-Fallow patterns. A high value crop (potato) may be included in the MV Boro-Fallow-MV T. Aman rotation suitable for irrigated medium high lands. The yield, gross return, gross margin, net return, and BCR of all six cropping patterns are found to be higher when PT is used for land preparation. The cropping intensity was found higher in the areas under PT compared to the areas under DAP. This result is supported by the earlier findings. Thus the findings indicate that there is a positive impact of power tiller to increase the profit to grow more crops in the same field round the year. Adoption of any suitable cropping pattern by using PT in Bangladesh is more profitable compared to use of DAP and farmers will be more benefited. Therefore, policy should be taken to adopt PT to improve the cropping patterns profitably and increase the cropping intensity at a large scale.

References

Alam, A. H. M. M. 1981. The Impact of Power Tillers on Productivity, Employment, and Income Distribution: A Case Study of Bangladesh. Paper presented at the Joint ADC/IRRI Workshop on the Consequences of Small Rice Farm Mechanization in Asia, IRRI, Los Banos, Philippines**.** 14-18 Sept.

Alam, M. Raisul. 2000. Impact of Mechanization on Livestock Farming and their Contribution to Primary Cultivation. *Journal of Agricultural Machinery and Mechanization*. Special Issue on Farm Power Options Vol. 4, No. 1.

Bangladesh Bureau of Statistics. BBS. 1996. Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

Bangladesh Bureau of Statistics. BBS. 2009. Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

Barton, David. 2000. Options for Farm Power Use in Primary Cultivation on Small Farms: Summary of Main Findings. *Journal of Agricultural Machinery and Mechanization*, Special Issue on Farm Power Options, Vol. 4, No. 1.

Binswanger, H P. 1977. The Economics of Tractors in South Asia: An analytical Review. ADC, New York, and International Crops Research Institute for the Semi-Arid Tropics, Hyderabad India.

Binswanger, H P.1981. Summary of Reactions and Discussion. In: Report of a Joint ADC/IRRI Workshop on the Consequences of Small Rice Farm Mechanization in Asia, IRRI, Los Banos, Philippines. 14-18 Sept.1981.

Bangladesh Rice Research Institute (BRRI). 1997. Annual Report for 1997, Gazipur-1701.

Bangladesh Rice Research Institute. BRRI. 2002. 19th National Workshop on Rice Research and Extension in Bangladesh. Feeding the Extra Millions by 2025-Challenges for Rice Research and Extension in Bangladesh. Bangladesh Rice Research Institute, Gazipur-1701. 29-31 January, 2002,

Bangladesh Rice Research Institute. BRRI. 2004. Twentieth National Workshop on Rice Research and Extension in Bangladesh. Emerging Technologies for Sustainable Rice Production. Bangladesh Rice Research Institute, Gazipur 1701, 19-21 April, 2004.

Dey, Pradip Kumar. 2006. Economic Impact of Power Tiller Mechanization in Bangladesh. Unpublished Ph. D Dissertation Submitted to the Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh.

Elahi, Nur-E-, A. H. Khan, M. R. Siddique, A. Shah, M. Nasim, M. I. U. Mollah and S. M. Shahidullah. 1999. Existing Cropping Patterns of Bangladesh, Potential Technologies and Strategies for Improving Systems Productivity, Proceedings of the BRRI-DAE Workshop on Modern Rice Cultivation in Bangladesh. BRRI, Gazipur-1700.February 14-16, .pp.107-171.

Gill. G.J. 1981. Farm Power in Bangladesh, Vol. 1. University of Reading. Deptt. of Agricultural Economics and Management, U.K.

Gill, G.J. 1983. Unpublished Report on Agricultural Research in Bangladesh, BARC, Dhaka, Bangladesh.

Howlader, M.M.Hoque, and Kamrul Huda. 2006. Experience, Prospect and Problems of Drum seeder and LCC Use for Rice Production at Farm Level (Bengali). Twenty first BRRI-DAE Joint Workshop, Bangladesh Rice Research Institute, Gazipur. Bangladesh, 19-21 September.

Khan, A.H., M.I.U. Mollah, M. Ibrahim, A. Khatun, M.A. Quddus, M. Hossain and M.S. Kadian. 2006. Double transplanting of Boro Rice: Potential Option for Optimizing Productivity of T. Aman-Potato-Boro Cropping Pattern. Twenty first BRRI-DAE Joint Workshop,. Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh, 19-21 September.

Ministry of Agriculture MoA. 2007. Handbook of Agricultural Statistics, Government of the People's Republic of Bangladesh.

Nakajud, A. R. B. 1972. Demand and Supply of Agricultural Labour in Relation to Mechanization in Thailand . Farm Mechanization in East Asia. Herman Southworth (eds). The Agricultural Development Council, New York and Singapore.

Quayum, M. A., M. A. Sattar and M. A. Rashid. 2006. Profitability Analysis of Cropping Pattern Testing under Irrigation in Some Selected Crop Diversification Programme Areas. *Journal of the Institution of Engineers, Bangladesh*, The Institution of Engineers, Bangladesh. Vol. **32**/AE. page 1-7.

Quayum, Muhammad Abdul. 2009. Impact of Power Tiller on Crop Output, Employment and Income in Bangladesh. Ph.D Thesis Submitted to the Department of Economics, in Fulfilment of the Requirement for the Degree of Doctor of Philosophy, Jahangirnagar University, Savar, Dhaka.

Quayum M. A. 2003. Comparative Study of Power Tiller and Bullock Power Utilization for MV Boro Rice Cultivation in Bogra District. Unpublished Report. Division of Agricultural Economics, BRRI, Gazipur-1700.

Quayum, M. A., M. A. S Azad and B. A. A. Mustafi. 2004. Boro rice cultivation under power tiller technology at Bogra district. *The Agriculturists* **2**(1): 117-125.