Comparative Profitability of Boro Rice Production Using Alternate Wetting and Drying and Conventional Irrigation in Some Selected Areas of Mymensingh Region[1]

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Abstract

This study looks at the economic profitability of Alternate Wet Drying (AWD) irrigation methods over conventional irrigation practices to address concerns of groundwater depletion associated with Boro rice production. In total 80 farmers of which 40 practice AWD and 40 farmers involved in conventional irrigation were selected randomly from Fulbaria and Trishal upazilas of Mymensingh district and Nakla and Nalitabari upazilas of Sherpur district. Descriptive as well as statistical analyses were done to achieve the objectives of the study. The key finding of the study is that AWD farmers gained more profit than conventional farmers on Boro rice production. The per hectare gross return and gross cost was higher and lower respectively in AWD farmers than conventional farmers from Boro rice production which ultimately leads higher net return of AWD farmers (Tk. 8621.456/hectare) than conventional farmers (Tk. 4551.204/hectare). The undiscounted Benefit Cost Ratio (BCR) was 1.111 and 1.057 respectively for AWD farmers and conventional farmers. The results indicated that application of AWD method was more profitable than conventional practices in Boro rice production. Significant difference was found in irrigation cost between conventional & AWD well owned farmers whereas there was no significant difference in irrigation cost between water hired conventional & AWD irrigation farmers but significant difference was found in profitability between conventional & AWD farmers. The study finally recommends the AWD method of irrigation should be disseminated every Boro rice producing area through the Department of Agricultural Extension (DAE).

1. Introduction

The economy of Bangladesh is primary dependent on agriculture, which contributes about 15.33 percent to the Gross Domestic Product (BER, 2016). Within the crop sector, rice dominates with an average 71 percent share of the gross output value of all crops (BBS, 2015). Bangladesh has a population of about 159.9 million with a growth rate of 1.37 percent per annum, giving a population density of 1063 per square kilometer (BER, 2016). The increasing rate of rice production has lessened slightly over the past few years compared to the rate of population

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increase. To meet the additional needs, the country imports rice every year. In Bangladesh, rice is grown in three distinct seasons: Boro (post-monsoon rice), Aus (pre-monsoon rice), and Aman (monsoon rice). Of the three types of rice, Boro rice alone contributes about 56 percent of total food grains, and is also the highest in productivity (3.965 MT per hectare) compared to Aus rice and Aman rice (BBS, 2015). Thus, the production of dry season irrigated rice has a predominant importance for national food security.

Bangladesh is the fourth largest rice producing country in the world (FAOSTAT, 2012) and third largest (FAPRI, 2009) consumer of rice in the world. About 79 percent of the total cropped area is planted to rice (BBS, 2015). Over 72 percent of the total irrigated area is planted to rice (BBS, 2015). Approximately 60 percent of the country's 1,91,92,164 metric tons rice production is grown during the dry (Boro) season and more than 78 percent of that is irrigated using groundwater resources (BBS, 2015). The environmental downside of Boro season cultivation is that agricultural pumping lowers the water table year on year as monsoonal recharge is insufficient to replenish the aquifers.

Despite the constraints of water scarcity, rice production and productivity have to rise in order to address the increased demand for rice driven largely by population growth and rapid economic development in Asia. Producing more rice with less water is therefore become a formidable challenge for achieving food, economic, social, and water security for the region.

In financial year 2014-15 Mymensingh was the topmost district in Boro rice production and production was 10,80,151 metric tons which is about 6 percent of total Boro rice production (1,91,92,164 metric tons) (BBS, 2015). In greater Mymensingh region, many farmers are devoted them in Boro rice cultivation. But in recent year’s farmers face water scarcity problem to irrigate rice field due to aquifer depletion; result of increasing daily extraction rate of groundwater in dry season.

Boro rice in Bangladesh, whether HYV or traditional varieties covering more than 48.43 lakh hectares, shares about 56 percent (BBS, 2015) of the total rice production is entirely irrigated, mostly with underground water. Farmers pay about 25-30 percent of the rice outlet for irrigation (Sattar *et al*., 2009). For producing 1 kg of paddy, it is estimated that a farmer has to use 3,000-5,000 liters of water for keeping ponded water during the growing stage of plants (BRRI-BRKB,

2017). However, this needs to be reduced to less than 2000 liters of water for one kilogram of rice. In flood irrigation method exposed water surface allows the highest water loss through evaporation. This presents another factor for the economic relevance of water-saving at the farm level. Experts state that on a national level, the implementation of AWD could save costs for irrigation of up to 56.4 million Euros in electricity or 78.8 million Euros in fuel or 30.0 liter diesel/ha (Miah, 2009). This method is very low-cost (the pipe only costs a few taka) and saves irrigation water costs without yield loss which in turn increases the profitability of farmers.

Several literatures were reviewed on application of AWD in producing Boro rice and related studies (Alam *et al.*, 2009; Hasan *et al*., 2016; Hossain, 2013; Husain *et al.*, 2009; Mishra *et al.*, 1990; Nalley *et al*., 2015; Price *et al*., 2013; Rahman and Angelsen, 2011). Most of the literatures focused on the effect of AWD and intermittent irrigation on water use efficiency, yield, irrigation payment systems, sustainability of AWD and probability of using water saving technology but very few of them focused on economic aspects of AWD to the farmers and economic comparison of AWD and conventional irrigation method. These are important issues from the standpoint of agricultural development, since all of it gives pertinent information useful for making sound management decisions, resource allocations, and for formulating agricultural policies and institutional improvement. Hence, the goal of present study are to compare the profitability of Boro rice production between AWD and conventional irrigation using farmers and to identify whether there is significant difference in profitability between two irrigation practices or not.

2. **Materials and method**

The study was conducted in the Mymensingh region which was designated purposively because Boro rice production had expanded tremendously in this district. Trishal and Fulbaria Upazila of Mymensingh district and Nakla and Nalitabari Upazila of Sherpur district were selected purposively. In collecting data at farmers' level, simple random sampling technique is followed. With the help of upazila agricultural officer and SAAO, a total of 80 sampled farmers directly involved in Boro rice cultivation are selected. Among them 40 farmers involved in conventional irrigation and another 40 farmers applied AWD, from whom information has been collected to accomplish this research. The pre-structured questionnaires were used to collect the data during the period from March to May 2016. Data on the costs and returns for one year Boro rice

production were collected from AWD and conventional irrigation practicing farmers. The conventional descriptive statistics were employed in analyzing the data. In order to test whether the irrigation cost and profitability of two methods differs significantly or not, non-parametric Mann-Whitney U test was used.

Per acre profitability of Boro rice production from the view point of AWD individual farmers and conventional farmers were measured in terms of gross return, gross margin, net return and benefit cost ratio (undiscounted).

Gross return (GR)

Gross return was calculated by multiplying the total volume of output of an enterprise by the average price in the harvesting period. The following equation was used to estimate GR.

$$GR_i = \sum_{i}^{n} Q_i P_i \quad \text{……(1)}$$

Where,

GR_i = Gross return from ith product (Tk/acre);

Q_i = Quantity of the ith product (kg/acre);

P_i = Average price of the ith product (Tk/kg); and i = 1, 2, 3 …..... n.

Gross margin (GM)

Gross margin was calculated by the difference between gross return and total variable costs. That is,

GM = GR- TVC……(2)

Where,
GM = Gross margin;

GR = Gross return; and

TVC = Total variable cost

Net return (NR)

Net return analysis considered fixed costs; cost of land rent, interest on operating capital etc. Net return was calculated by deducting all costs (variable and fixed) from gross return. To determine the net return of Boro production by using AWD, the following equation was used in the present study:

NR = GR- TC……..(3)

Where,
NR= Net return (Tk. /hectare)

GR = Gross return (Tk./hectare); and

TC = Total cost (Tk./hectare)

In this study, cost and return analysis was done on both variable and total basis. The following profit equation was developed to assess the profitability of fish production:

π = Gross return - (Variable cost + Fixed cost)…….....(4)

Here,

π= Profit per hectare;

Benefit-Cost Ratio (BCR)

The benefit cost ratio (BCR) is a relative measure which is used to compare benefit per unit of cost. BCR was estimated as a ratio of gross return and gross costs. The formula of calculating BCR (undiscounted) is shown as below:

Benefit Cost Ratio (BCR) = $\frac{\text{Gross Benefit}}{\text{Gross Cost}}$……..……..…(5)

Mann- Whitney U-test

To test whether the amount of water used by two methods differs significantly or not the Mann- Whitney U-test were applied. In this test, the scores obtained by two individual samples are ranked together, giving rank 1 to the lowest score. If ties occur between two or more observations in the same group, the value of U is not affected. But if ties occur between two or more observations involving both groups, the value of U is affected. Although the effect is usually negligible, a correction for ties is available for use with the normal curve approximation employed for larger samples. To those ranks that are tied assign the average of the tied ranks. The ranks received by the two sets of scores are then separately summed up to obtain R_1 and R_2. To determine the value of U, the following formula was used.

$$U_1 = N_1N_2 + \frac{N_1(N_1+1)}{2} - \sum R_1 \quad \text{.....(6)}$$

$$U_1 = N_1N_2 - U_2 \quad \text{.....(7)}$$

Or, equivalently

$$U_2 = N_1N_2 + \frac{N_2(N_2+1)}{2} - \sum R_2 \text{.....(8)}$$

$$U_2 = N_1N_2 - U_1 \text{.....(9)}$$

Where,

N_1= number of items in the first group (Conventional farmer)

N_2= number of items in the second (larger) group (AWD farmer)

R_1= sum of ranks of first group

R_2= sum of ranks of second group

The smaller of U_1 and U_2 is the Mann-Whitney U. If N_2 is larger than 20, the observed value of U may be transformed to Z value as given by the formula:

$$z = \frac{U - \left(\frac{N_1N_2}{2}\right)}{\sqrt{\frac{N_1N_2(N_1+N_2+1)}{12}}} \text{.....(10)}$$

The significance of Z may be tested by consulting table of Seigel (1988), i.e. table A of probabilities associated with values as extreme as observed values of z in normal distribution (Seigel, 1988).

3. Empirical Results

3.1 Scenario of comparative cost and return

Data on different production input costs and returns from the AWD and conventionally irrigated plots in study locations are presented in Table 1 and 2. In the study areas variable costs included cost of using human labor, power tiller, seed/seedlings cost, fertilizer, irrigation, pesticides. Considering all locations, it was observed that average labour cost per hectare was estimated at Tk. 21,070.620 (27.76 percent of total gross cost) in case of AWD practice which was lower than the conventional practice as it covers 28.91 percent of gross cost. In the study areas, farmers used

power tiller on the basis of rent. Average per hectare power tiller cash cost for tillage operation was higher in AWD practice than the conventional practice and per hectare seed cost was relatively higher for AWD farmer than that of conventional farmer because most of the seed used by the AWD farmer were purchased from the open market at a higher price. Fertilizer requirement for AWD farmer was also higher than the conventional farmer whereas AWD practices required less irrigation cost (Tk. 11,250.700) than conventional practices (Tk. 12,123.650) on per hectare basis in the study areas. Insecticides cost of AWD farmers were also lower than the conventional farmers.

It is observed that the total per hectare variable cost was Tk. 59,060.620 for conventional farmers which in covers 74.42 percent of gross cost and on the other hand, it was estimated at Tk. 57,949.710 for AWD farmers which shared 74.97 percent of gross cost. Fixed costs in this study include land use cost and interest on operating capital and depreciation cost. Conventional farmers fixed cost covers 25.58 percent of gross cost whereas for AWD farmers it shared 25.03 percent of gross cost. Annual per hectare cost of rice production was estimated on the basis of gross cost. It appears from Table 1, that per hectare gross costs of Boro rice production of conventional farmers was estimated at Tk. 75,144.890 in Fulbaria Tk. 92,663.280 in Trishal, Tk. 83,638.520 and Tk. 65,226.790 in Nalitabari and Nakla respectively. Considering all the conventional sample farmers of all areas gross cost was estimated Tk. 79,363.150. In case of AWD farmers per hectare gross cost was Tk. 61,187.910 in Fulbaria, Tk. 87,720.940 in Trishal, Tk. 88,295.490 and Tk. 71,419.190 in Nalitabari and Nakla respectively (Table 2). Considering all the AWD sample farmers gross cost was estimated Tk. 77,302.980 which is lower than that of conventional practices in the study areas because of less human labor cost, irrigation cost and insecticides cost in AWD practice.

Per hectare gross return in Fulbaria, Trishal, Nalitabari and Nakla was Tk. 84,655.130, Tk. 93,492.240, Tk. 89,016.590 and Tk. 69,821.620 respectively from Boro rice production of conventional farmers. Per hectare gross returns from Boro rice production of AWD farmers was estimated at Tk. 76,212.170 in Fulbaria, Tk. 91,395.700 in Trishal, Tk. 97,544.710 and Tk. 77,714.140 in Nalitabari and Nakla respectively. Considering all the sampled AWD farmers per hectare gross return was estimated at Tk. 85,924.440 which is higher than conventional farmers which gross return per hectare was at Tk. 83,914.350 (Table 1 and 2).

Considering all location conventional farmers per hectare gross margin was estimated at Tk. 24,853.740 for Boro rice production and Tk. 27,974.730 was for AWD farmers. So, it was impressive from the results that the gross margin of AWD farmers was greater than that of conventional farmers. Per hectare net return from AWD farmer was higher than that of conventional farmer in every upazila and considering all AWD sampled farmers it was estimated at Tk. 8,621.456 which is higher than that of conventional farmers (Tk. 4,551.204/hectare). So per hectare profitability was higher in AWD practice than conventional practice.

BCR (undiscounted) of AWD and conventional practice was emerged as 1.111 and 1.057, respectively implying that Tk. 1.111 and Tk. 1.057 would be earned by investing every Tk. 1.00 in AWD and conventional practice for Boro rice production. So, it was observed BCR 1.111 of AWD practice for Boro rice production was higher compared to that of conventional practice. Overall it can be concluded that AWD practice for Boro rice production would be more profitable than conventional irrigation practice.

Table 1: Per hectare cost-return and profitability of Boro rice farming with conventional practice

Items	Fulbaria	Trishal	Nalitabari	Nakla	Average	Percentage
Variable cost						
Labour	21501.670	32521.670	20061	17938.330	22946.960	28.91
Power tiller	5493.386	11680.740	6285.949	4785.031	7155.981	9.02
Seed/Seedlings	3196.856	3449.767	3124.107	2668.919	3087.130	3.89
Fertilizer	12239.220	14888.340	11422.710	11350.040	12438.780	15.67
Irrigation	16895.810	11856	14131.940	7970.153	12123.650	15.27
Insecticide	577.980	2030.889	1333.049	997.767	1308.119	1.66
A. Total variable cost	59904.922	76427.406	56358.750	45710.240	59060.620	74.42
Fixed cost						
Land use cost	10087.100	10337.160	22131.200	15234.090	15209.500	19.16
Interest on operating capital	4492.869	5732.055	4226.906	3428.268	4429.546	5.58
Depreciation (Tk./yr)	660	166.667	921.667	854.20	663.490	0.84
B. Total fixed cost	15239.970	16235.880	27279.770	19516.560	20302.530	25.58
C. Total cost (A+B)	75144.890	92663.280	83638.520	65226.790	79363.150	100
Return from Boro rice production						
Main product (Maund)	136.547	153.689	154.804	113.157	139.575	
Price (Tk./Maund)	602	582.2222	558	592	580.882	
Return (Tk.)	83028.730	89348.130	86343.300	67003.210	80963	
By product (Tk.)	1626.400	4144.111	2673.294	2818.415	2951.355	
D. Gross return	84655.130	93492.240	89016.590	69821.620	83914.350	
E. Gross margin (D-A)	24750.210	17064.850	32657.840	24111.390	24853.740	
F. Net return (D-C)	9510.246	828.966	5378.070	4594.832	4551.204	
BCR	1.127	1.009	1.064	1.070	1.057	

Source: *Authors' estimation based on field survey, 2016.*

Table 2: Per hectare cost-return and profitability of Boro rice farming with AWD practice

Items	Fulbaria	Trishal	Nalitabari	Nakla	Average	Percentage
Variable cost						
Labour	13390.250	30147.780	21305.760	19257.390	21070.620	27.76
Power tiller	5603.309	11168.180	6162.954	6398.592	7357.225	9.52
Seed/Seedlings	3013.400	3795.250	4823.324	2015.819	3447.746	4.46
Fertilizer	9437.313	15997.290	13341.130	14761.290	13348.950	17.27
Irrigation	15971.150	9704.250	12547.500	6283.154	11250.700	14.55
Insecticide	465.975	1199.850	1407.641	1318.829	1092.414	1.41
A. Total variable cost	47881.390	72012.590	59588.300	51690.630	57949.710	74.97
Fixed cost						
Land use cost	9085.416	9927.405	23761	14921.210	14411.100	18.64
Interest on operating capital	3591.104	5400.945	4469.123	3876.797	4346.228	5.62
Depreciation (Tk./yr)	630	380	476.666	930.556	595.940	0.77
B. Total fixed cost	13306.520	15708.350	28707.190	19728.560	19353.270	25.03
C. Total cost (A+B)	61187.910	87720.940	88295.490	71419.190	77302.980	100
Return from Boro rice production						
Main product (Maund)	127.256	158.849	175.708	125.922	147.472	
Price (Tk./Maund)	585	549	537	592.777	565.256	
Return (Tk.)	74529.400	86880.350	94790.470	74739.210	82939.880	
By product (Tk.)	1682.767	4515.350	2764.236	2974.924	2984.560	
D. Gross return	76212.170	91395.700	97554.710	77714.140	85924.440	
E. Gross margin (D-A)	28330.770	19383.110	37966.410	26023.510	27974.730	
F. Net return (D-C)	15024.250	3674.757	9259.218	6294.944	8621.456	
BCR	1.246	1.042	1.105	1.088	1.111	

Source: *Authors' estimation based on field survey, 2016.*

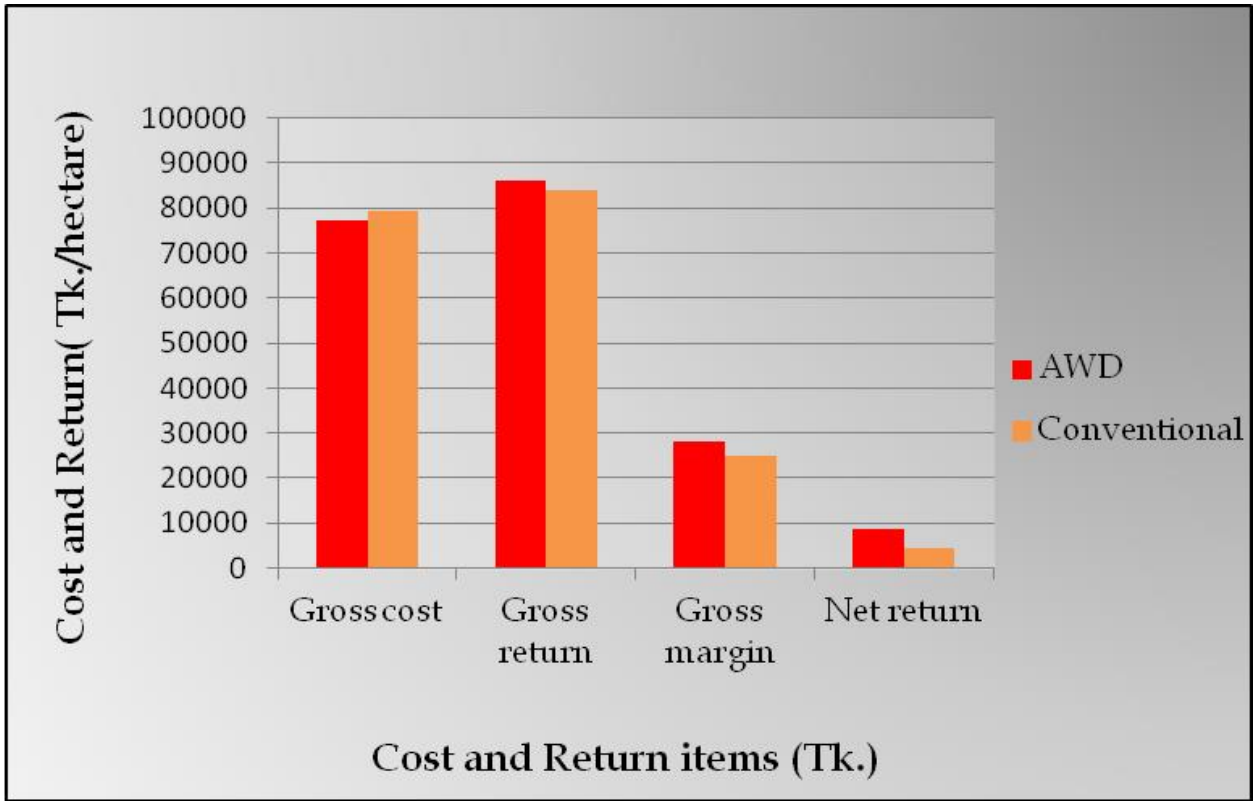

Figure 1: Cost and return of Boro rice production by applying two irrigation practices

From Figure 1, it was evident that per hectare gross cost for producing Boro rice is higher for conventional farmers than AWD farmers which lead higher gross return, net return and gross margin for AWD practicing farmers than conventional irrigation practicing farmers.

3.2 Significant difference test of irrigation cost

By using Mann-Whitney U test as alternative of t-test to test whether the irrigation cost of two methods differs significantly or not from Table 3, it was found that the Mann-Whitney U test statistic is 240.500 and 31.500 for well owned and irrigation water hired farmers' respectively and there is significant difference in irrigation cost between conventional and AWD well owned farmers. But in case of irrigation water hired farmers there is insignificant difference in irrigation cost between two methods because here farmers bought water at fixed rate per acre on contractual basis for one season. As they paid a fixed amount of taka for irrigation water without

taking consideration of water amount so they did not pay so much concern for water saving. So in the study areas water saving technology was not efficiently utilized by irrigation water hired farmers. Overall Mann- Whitney u test statistic was 566.500 and it is insignificant so overall there is no significant difference in irrigation cost between conventional and AWD farmers as most of the farmers in the study areas were irrigation water hired farmers.

Table 3: Results of Mann-Whitney U test of irrigation cost difference

Source of irrigation	Hypothesis	Mann-Whitney U test		Comment
		Statistic	p value	
Owner	There is no significant difference in irrigation cost between conventional and AWD well owned farmers.	240.500	0.032**	Rejected
Hired	There is no significant difference in irrigation cost between water hired conventional and AWD irrigation farmers.	31.500	0.302	Accepted
Overall	There is no significant difference in irrigation cost between conventional and AWD farmers.	566.500	0.285	Accepted

Source: *Authors' estimation, 2016.*
Note: **Significant at 5 percent level.

3.3 Significant difference test of profitability

To test whether the profitability of two methods differs significantly or not, by using non parametric Mann-Whitney U test it was found that the Mann-Whitney U test statistic is 508 (Table 4) and it is significant at 10% level of significance which indicates there is significant difference in profitability between conventional and AWD farmers.

Table 4: Results of Mann-Whitney U test of profitability difference

Hypothesis	Mann-Whitney U test		Comment
	Statistic	p value	
There is no significant difference in profitability between conventional and AWD farmers.	508	0.087*	Rejected

Source: *Authors' estimation, 2016.*
Note: * Significant at 10 percent level.

Conclusions and recommendations

In the study areas Boro rice production was more profitable under AWD practice than conventional irrigation practice as the per hectare irrigation cost of AWD farmer (Tk. 11,250.700) was lower than the conventional farmer (Tk. 12,123.650/ hectare). The use of AWD method would render an eventual profit of Tk. 4070.252 per hectare instead of using the conventional irrigation. BCR was also higher for AWD farmers than conventional farmers. It was evident from the Mann-Whitney U test that there is significant difference in irrigation cost between well owned conventional and AWD farmers' and significant profitability difference was found between conventional and AWD farmers. As application of AWD is profitable and has environmental and climatic benefits, thus there is an ample scope to decrease production cost by reducing irrigation cost in major Boro rice producing areas by practicing AWD method of irrigation. The study finally recommends the AWD method of irrigation should be disseminated every Boro rice producing area through the Department of Agricultural Extension (DAE). The authorities who know the benefits of AWD well in terms of profit, water saving and environmental benefit should play proper role to take it in the policy level. Only then this AWD method of irrigation will get institutional recognition and the ultimate users, farmers of this country will enjoy its benefit directly and that will protect our environment in long run.

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Appendix Table 1

Test Statistics of irrigation cost difference between conventional and AWD well owned farmers

	Irrigation
Mann-Whitney U	240.500
Wilcoxon W	646.500
Z	-2.149
Asymp. Sig. (2-tailed)	0.032

Appendix Table 2

Test Statistics of irrigation cost difference between conventional and AWD irrigation water hired farmers

	irrigation
Mann-Whitney U	31.500
Wilcoxon W	67.500
Z	-1.033
Asymp. Sig. (2-tailed)	.302
Exact Sig. [2*(1-tailed Sig.)]	0.310[b]

Appendix Table 3

Test Statistics of irrigation cost difference between conventional and AWD farmers

	Irrigation
Mann-Whitney U	566.500
Wilcoxon W	1346.500
Z	-1.070
Asymp. Sig. (2-tailed)	0.285

Appendix Table 4

Test Statistics of profitability difference between conventional and AWD farmers

	Method
Mann-Whitney U	508.000

Wilcoxon W	1103.000
Z	-1.714
Asymp. Sig. (2-tailed)	0.087