CHAPTER 6

ECONOMIC ANALYSIS OF RICE PRODUCTION

This section deals with the costs and returns of rice production in two production environments (irrigated and rainfed) for spring and summer seasons with two planting methods (transplanting and broadcasting). The purpose is to investigate the implication of cultivation of each planting method in different seasons in terms of the cost of production, input requirements, the profitability of production and the output response to inputs.

Costs and returns are calculated at actual prices paid and received by the farmers to see which planting method is better in terms of net profit and returns to labour and materials, as well as family income. The prices of inputs that are traded, and thus have a market value such as chemical fertilizers, pesticides, herbicides are easy to obtain. However, the value of manure is difficult to evaluate because it is not normally sold or bought. For land preparation, farmers use buffaloes, tractors, and labor prior to planting. If farmers used buffaloes to till the land once before tractor puddling it could reduce the costs for tractors. Some farmers use buffalo to level land after tractor pudding and so the cost for leveling is very cheap. In this case costs of land preparation would include buffalo, and tractor and are placed under machine cost category.

The production functions are estimated to find the response of yield to the inputs used. The different production environments and planting methods as well as the different planting seasons are expected to have strong effect on rice productivity.

6.1. Profitability of irrigated lowland rice production.

6.1.1. Profitability of transplanted rice in spring season

The average cost of transplanted rice production in the spring season is 320.6 thousand VND per sao, comprised of 128.0, 131.1, and 41.5 thousand VND of material costs, labour costs and machinery, and land tax accounted for 40%, 41%, and 19% of total cost, respectively.(Table 22)

Table 22: Factor costs and returns from irrigated rice production of different planting methods

Iterns	Spring season			Summer season		
	Tr (n=60)	Br (n=60)	Mean (n=60)	Tr (n=60)	Br (n=60)	Mean
Total revenue(1000 VND/sao)	429.5	420.8	425.0	362.7	364.0	363.0
Material input (1000VND/sao)	128.0	131.7	129.8	111.6	119.4	115.3
Labour (1000 VND/sao)	131.1	116.6	124.0	124.6	110.5	117.5
Machine cost (1000 VND/sao)	44.5	49.8	47.1	44.8	46.7	45.8
Land tax (1000 VND/sao)	16.9	16.7	16.8	16.9	16.5	16.7
Total cost (1000 VND/sao)	320.6	314.8	317.8	297.9	293.2	295.3
Cost of 1 kg of rice (1000VND/kg)	1.3	1.3	1.3	1.4	1.4	1.4
Net return (1000 VND/sao)	108.9	106.0	107.3	64.8	70.9	67.7
Return to labour (1000VND/day)	36.3	38.0	37.1	30.3	32.9	31.6
Return to material	2.4	2.3	2.4	2.1	2.2	2.1

Source: survey 1998

Note: Tr-Transplanting rice Br- Broadcasting rice

The sale price of rice is calculated at the farm gate and is usually dependent upon the market price. In the spring season and the summer season the rice price obtain is 1700 VND per kilogram. For the transplanting rice in the spring season, farmers obtained total revenue, return to labour, return to material cost and net return of 429.5, 36.3, 2.4, and 108.9 thousand VND per sao, respectively.

6.1.2. Profitability of broadcasting rice in the spring season in the irrigated regions

As presented in Table 22, the broadcasting rice under irrigated condition in the spring season has average production costs of 314.8 thousand VND per sao. The cost of material contributed is slightly higher than the cost of labour at 131.7 and 116.6 thousand VND respectively. The costs of land preparation for broadcasting rice is higher than the cost of transplanting rice in the same planting season. The farmers obtain return to material and return to labour income are lower in comparison to transplanting rice. Total revenue, net return are 420.8, 106.0, thousand VND, respectively, but lower than that of transplanting rice. The return to labour by broadcasting method achieves 38.0 thousand VND which is higher than transplanting rice in the spring season (36.3 thousand VND).

6.1.3. Profitability of transplanting rice in the summer season in the irrigated lowlands.

The average costs of transplanting rice production in the summer season are 297.9 thousand VND per sao, labour cost contributes the highest percentage of the total cost (42%) followed by material costs (37%). The total revenue from selling rice is 362.7 thousand VND per sao. The return to labour was 30.3 thousand VND per manday and return to materials is 2.13 times, which is lower than both transplanting and broadcasting rice in the spring season. The cost of producing one kilogram of rice (1.42) is higher than the cost of one kilogram of rice in the spring season . The data in Table 22 also indicates that the net profit for transplanting rice in the summer season was 64.7 thousand VND per sao.

6.1.4. Profitability of broadcasting rice in the summer season in the irrigated condition.

The results of the economic analysis of broadcasting rice in summer are presented in Table 22 which show that broadcasting rice has a production cost of 293.2 thousand VND per sao. These costs are comprised of 119.4, 110.5, 63.2 thousand VND of material costs, labour costs and machine costs per sao, respectively, so these contributes 40.7, 37.4, 21.5% of the total cost. For the broadcasting rice in the summer season rice production provide a total revenue of 364.4 thousand VND per sao. The results from Table 22 reveal that farmers earn a return to material of 2.2, return to labour of 32.9 thousand VND per manday, this also show a value higher than for transplanting rice in the same planting season and water conditions.

In conclusion, the total costs for transplanting rice is higher than for broadcasting rice in the spring season as well as in the summer season. The total cost of the spring season rice is higher in comparison to summer rice for both planting methods.

6.1.5. Profitability of transplanting rice in the spring season of the rainfed lowlands.

The return to labour of broadcasting rice is higher than for transplanting rice in both planting seasons, therefore, the return to labour for broadcasting rice is higher in comparison to transplanting rice in both the spring and summer seasons. However, farmers achieve a net return for broadcasting rice in the summer season higher than that of transplanting rice in the same planting season.

6.1.6. Profitability of transplanting rice in the summer season in the rainfed lowlands.

As presented in Table 23, the transplanting rice in the summer season has average production costs of 161.88 thousand VND per sao. The cost of materials, labour and machinery contribute 23.06, 52.87, 23.47% respectively. Thus the contribution of labour costs for transplanting rice in the rainfed areas are higher than in the irrigated area but different to transplanting costs in the spring season. The analysis reveals that the net return is positive. The return to labour and return to material are also higher than that of transplanting rice in the spring season in the rainfed region.

6.1.7. Profitability of broadcasting rice in the summer season in the rainfed lowlands.

The results from Table 23 above show that the total cost of broadcasting rice is 276.45 thousand VND per sao. The costs of materials and labour contribute nearly equal percentages with around 40.%. Machinery costs and land tax are 17.6%, but it is found that the return to labour and return to materials are not higher in comparison to transplanting rice in the same planting season.

Table 23: Factor shares and return from rainfed rice production by different planting method

Iterms	Spring season	Summer season		
	Tr (n=60)	Tr (n=30)	Br (n=30)	Mean
Total revenue *(1000 VND/sao)*	153.42	193.97	310.88	252.43
Material input (1000 VND/sao)	43.09	37.35	111.74	74.54
Labour (1000 VND/sao)	99.99	85.66	115.18	100.42
Machine cost (1000 VND/sao)	39.91	29.65	37.64	33.64
Land tax (1000 VND/sao)	10.20	9.25	11.89	10.56
Total cost *(1000 VND/sao)*	193.18	161.89	276.46	219.17
Cost of 1 kg of rice(1000 VND/sao)	2.37	1.45	1.52	1.48
Net return(1000 VND/kg)	-39.77	32.09	34.43	33.25
Return to labour (1000 VND/day)	11.54	27.65	27.65	27.65
Return to material	1.26	2.97	1.76	2.37

Source: survey 1998

Note: Tr-Transplanting rice ; Br- Broadcasting rice

6.2. Comparison of costs and return of transplanting rice and broadcasting rice production.

6.2.1. Comparison of transplanting rice and broadcasting rice in the spring season in irrigated region.

As presented in Table 24, the total cost, production, total revenue, cost of one kilogram as well as net profit of transplanting rice and broadcasting rice in the spring season in irrigated environment are not significantly different, but the return to labour is significant different

Table 24: Comparison of cost and return in irrigated rice production by planting method in the spring season

Items	Planting methods		Different	T-ratio	Sig T
	Transplanting (n=60)	Broadcasting (n=60)			
Total revenue (.000 VND)	429.29	420.76	8.52	.83	.411
Total cost (.000 VND)	320.76	314.75	6.012	.86	.392
Cost of 1 Kg (.000 VND)	1.30	1.29	.008	.22	.827
Net return (.000 VND)	108.52	106.01	2.51	.26	.795
Return to labor(.000 VND)	36.17	38.03	-1.85	-1.22	.229
Return to material	2.40	2.32	0.075	1.00	.323

Source: survey 1998

6.2.2. Comparison of costs and returns of transplanting rice and broadcasting rice in the irrigated lowlands in the summer season by planting method.

As presented in Table 25, the production, total revenue and return to material of broadcasting rice are higher and not significantly different from transplanting rice

Table 25: Comparison of cost and return in the irrigated rice production by planting method in summer season

Items	Planting method		Different	T-ratio	Sig- T
	Tr (n=60)	Br (n=60)			
Total revenue(1000 VND/sao)	361.94	364.03	-2.09	-.30	.76
Total cost (1000 VND/sao)	297.46	293.19	4.27	0.91	.36
Cost of 1 Kg (1000 VND/sao)	1.42	1.37	.041	1.91	.06
Net return (1000 VND/sao)	64.47	70.85	-6.38	-1.23	.22
Return to labor (,000 VND/day)	30.25	32.9	-2.66	-3.11	.00
Return to material	2.13	2.15	-.022	-.54	.60

Source: survey 1998

Note: Tr = Transplanting; Br = Broadcasting

While net profit and return to labour of broadcasting rice are high and significantly different when compare to transplanting rice in the summer season.

The results from Table 25 reveal that the cost of one kilogram of rice of transplanting rice are higher than for broadcasting rice.

6.2.3. Comparison of costs and returns of transplanting rice and broadcasting rice in the rainfed lowlands in the summer season by planting method.

The total costs of broadcasting rice in the rainfed area in the summer season were significantly higher than those of transplanting rice, the results also reveal that high production cost of one kilogram for broadcasting rice (Table 26). However, the return to material value of transplanting rice is higher than for broadcasting rice.

Table 26 : Comparison of costs and returns in rainfed rice production by planting method in summer season

Items	Planting method		Different	T-value	SigT
	Tr (n=30)	Br (n=30)			
Total revenue (1000 VND/sao)	193.96	310.88	-116.92	-17.33	.000
Total cost (1000 VND/sao)	161.88	274.45	-114.57	-17.96	.000
Cost of 1 Kg (1000 VND/kg)	1.44	1.52	-.075	-1.72	.095
Net return(1000 VND/sao)	32.07	34.42	-2.34	-.33	.74 0
Return to labor (1000VND/day)	27.64	27.65	-.01	.000	.997
Return to material	2.97	1.75	1.22	7.08	.000

Source: survey 1998

Note: Tr = Transplanting ; Br= Broadcasting

All of the items of production and return of broadcasting rice are higher than those of transplanting rice but net profit, and return to labour are not significantly different between the two planting methods.

6.3. Analysis of production functions.

In this part, seven production functions of transplanting and broadcasting in both rainfed and irrigated environments are estimated. The investigation aims to explore the responses of rice to keys inputs used including: manure, nitrogen, phosphate, potassium fertilizers as well as labour, herbicide and pesticide inputs. The response is measured in terms of their effects on grain yield. Based upon the results, recommendations are also made to improve technical efficiency in rice production of both systems.

6.3.1. Model specification

In this study, the production function of each system is investigated by the ordinary least square (OLS) method. The selection of the appropriate model is based on the sign and significant level of the estimated coefficients. In addition, an estimated regression function should be capable of explaining the sample observations of each of the dependent variables with some degree of accuracy. The coefficient of the determination (R^2 or adjusted R^2) is taken into consideration for the best fit of the model (Studenmund, 1992). By the criteria, the selected final estimation model for each production function is listed in the Table 27.

Table 27: Model specification

Production systems	Model
Transplanting rice in the irrigated area in the spring season	$Y_1 = f_1$(Mn, N, P, K, Lb, H, Ps,e_1)
Transplanting rice in the irrigated area in the summer season	$Y_2 = f_2$(Mn, N, P, K, Lb, H, Ps,e_2)
Broadcasting rice in the irrigated area in the spring season	$Y_3 = f_3$(Mn, N, P, K, Lb,H , Ps,e_3)
Broadcasting rice in the irrigated area in the summer season	$Y_4 = f_4$(Mn, N, P,K , Lb, H, Ps, e_4)
Transplanting rice in the rainfed area in the spring season	$Y_5 = f_5$(Mn, N, P, K, Lb, Ps,e_5)
Transplanting rice in the rainfed area in the summer season	$Y_6 = f_6$(Mn, N, P, K, Lb, Ps,e_6)
Broadcasting rice in the rainfed area in the summer season	$Y_7 = f_7$(Mn, N, P, K, Lb, H, Ps, e_7)

Note: Variables specified in model are described as follows:

Yield : The average yield of rice in each production method (kg / sao)

Mn : Manure (kg / sao)

N : Urea (kg / sao)

P : Phosphate super (kg / sao)

K : Potassium KCl (kg/ sao)

Lb : Total labour (manday / sao)

H : Herbicide cost (VND/ sao)

Ps : Pesticide cost (VND / sao)

e : Error term

6.3.2. Descriptive statistics of the yield and input variables.

The descriptive statistics in terms of mean, standard deviation, minimum and maximum of each variable in all models are presented in Tables 28a, 28b and 29. The figures show that there are very small variation of input variables, however these have caused some limitations to the estimated production functions.

Table 28a: Descriptive statistics of the yield and input variables

Variables	Mean	SD	Minimum	Maximum
Transplanting rice in the spring season in irrigated area (n=60)				
Yield (kg/sao)	252.6	53.0	150.0	400.0
Manure (kg/sao)	168.4	86.3	0.0	350.0
Nitrogen (kg/sao)	11.9	2.1	8.3	16.0
Phosphate super (kg/sao)	14.3	4.1	6.7	24.0
Potassium (kg/sao)	4.8	1.45	3.0	7.3
Labour (manday/sao)	6.8	0.52	5.6	8.0
Herbicide (VND/sao)	4134.4	3662.6	0.0	10666.7
Pesticide(VND/sao)	22713.7	10450.1	5000.0	40000.0
Transplanting rice in the summer season in irrigated area (n=60)				
Yield (kg/sao)	215.0	32.4	157.7	280.0
Manure (kg/sao)	127.8	36.0	80.0	250.0
Nitrogen (kg/sao)	10.9	1.39	8.8	15.0
Phosphate super (kg/sao)	13.0	3.5	7.7	21.0
Potassium KCl (kg/sao)	4.0	1.49	0.0	7.0
Labour (manday/sao)	6.2	0.6	5.1	7.5
Herbicide (VND/sao)	4505.1	3784.5	0.0	10668.0
Pesticide (VND/sao)	18458.2	6619.85	7500.0	40000.0

Table 28b: Descriptive statistics of the yield and input variables

Variables	Mean	SD	Minimum	Maximum
Broadcasting rice in the spring season in irrigated area (n=60)				
Yield (kg/sao)	247.5	41.9	150.0	350.0
Manure (kg/sao)	190.4	75.4	0.0	360
Nitrogen (kg/sao)	12.4	1.4	9.0	15.0
Phosphate super (kg/sao)	14.2	3.9	0.0	22.0
Potassium (kg/sao)	4.5	1.3	0.0	7.0
Labour (manday /sao)	5.8	0.58	4.8	7.2
Herbicide (VND/sao)	8335.6	890.9	6000.0	10656.7
Pesticide(VND/sao)	26702.9	8295.3	11792.4	50000.0
Broadcasting rice in the summer season in irrigated area (n=60)				
Yield (kg/sao)	214.1	28.3	150.0	300.0
Manure (kg/sao)	134.1	52.3	0.0	250.0
Nitrogen (kg/sao)	11.8	1.4.5	8.2	15.0
Phosphate super(kg/sao)	12.0	2.9	8.6	20.0
Potassium(kg/sao)	3.3	1.6	0.0	6.0
Labor(manday/sao)	5.5	0.58	4.0	7.0
Herbicide(VND/sao)	8169.4	864.3	6300.0	11333.0
Pesticide(VND/sao)	20709.3	6633.0	10000.0	47619.0

Table 29: Descriptive statistics of the yield and input variables

Variables	Mean	SD	Minimum	Maximum
Transplanting rice in the spring season in rainfed area (n=60)				
Yield (kg/sao)	90.2	33.6	44.0	150.0
Manure (kg/sao)	40.2	50.1	0.0	150.0
Nitrogen (kg/sao)	5.9	1.2	3.0	8.3
Phosphate super (kg/sao)	11.7	3.5	5.0	22.2
Potassium (kg/sao)	0.8	1.2	0.0	5.0
Labour (manday /sao)	5.0	0.8	3.6	7.5
Pesticide (VND/sao)	1857.	3571.4	0.0	1666.3
Transplanting rice in the summer season in rainfed area (n=30)				
Yield (kg/sao)	114.1	19.1	80.6	162.2
Manure (kg/sao)	31.3	41.8	0.0	120.0
Nitrogen (kg/sao)	5.2	0.6	4.0	6.5
Phosphate super (kg/sao)	10.9	2.0	8.0	15.0
Potassium (kg/sao)	0.4	0.9	0.0	3.0
Labour (manday/sao)	4.3	0.6	3.2	5.5
Pesticide (VND/sao)	1573.5	2002.4	0.0	5357.1
Broadcasting rice in the summer season in rainfed area (n=30)				
Yield (kg/sao)	182.9	14.8	150.0	200.0
Manure (kg/sao)	134.0	39.1	75.0	200.0
Nitrogen (kg/sao)	10.2	1.7	6.0	12.5
Phosphate super (kg/sao)	13.8	2.7	9.0	18.0
Potassium (kg/sao)	4.1	1.0	2.0	5.5
Labour (manday/sao)	5.6	0.5	4.6	6.5
Herbicide (VND/sao)	7952.6	1123.5	6000.0	10666.7
Pesticide (VND/sao)	14288.0	3287.8	8000.0	22200.0

6.3.3. Simple correlation among explanatory variables.

Simple correlation among explanatory variables for each production method presented in Tables 30a, 30b and Table 31 is generally not high in absolute value.

Table 30a Simple correlation among explanatory variables for irrigated rice production system

Transplanting rice in the spring season in irrigated area (n = 60)							
	Yield	Manure	Nitrogen	Phospho	Potass	Labour	Herbi
Manure	.8047						
Nitrogen	.8196	.7132					
Phosphorus	.7399	.5375	.6577				
Potassium	.8960	.7039	.7203	.6785			
Labour	.7712	.6437	.6313	.4949	.6910		
Herbicide	.5225	.3469	.5218	.3910	.5544	.3927	
Pesticide	.0941	.0397	.1436	.0874	.0558	.1050	.1017

Broadcasting rice in the spring season in irrigated area (n=60)							
	Yield	Manure	Nitrogen	Phospho	Potass	Labour	Herbi
Manure	.7059						
Nitrogen	.3928	.0519					
Phosphorus	.7109	.4745	.4138				
Potassium	.6453	.4700	.1009	.4284			
Labour	.6677	.5870	.2297	.3942	.5395		
Herbicide	.4906	.3961	.1365	.2210	.3139	.4708	
Pesticide	.0427	.1586	.1620	.1650	-.0683	.1234	.3271

Multicollinearity arises when some or all the explanatory variables are highly correlated reducing the precision of estimation. Among simple way of checking multicollinearity is to check simple correlation coefficient among explanatory variables. Since there is no specific rule, correlation coefficients greater than 0.80 among the explanatory variables is used to indicate existence of severe multicollinearity (Studenmund, 1992)

Table 30b: Simple correlation among explanatory variables for irrigated rice production system

Transplanting rice in the summer season in irrigated area (n = 60)							
	Yield	Manure	Nitrogen	Phospho	Potass	Labour	Herbi
Manure	.7437						
Nitrogen	.6186	.4643					
Phosphorus	.7430	.5236	.5231				
Potassium	.8574	.5832	.6124	.6259			
Labour	.6320	.6957	.3292	.3299	.4887		
Herbicide	.5975	.5473	.4617	.4718	.6384	.3574	
Pesticide	.0842	3217	.0458	.2455	.0614	.3334	.1015
Broadcasting rice in the summer season in irrigated area (n=60)							
	Yield	Manure	Nitrogen	Phospho	Potass	Labour	Herbi
Manure	.6609						
Nitrogen	.4951	.2984					
Phosphorus	.4441	.3308	.3478				
Potassium	.3427	.3873	.1742	.3278			
Labour	.4226	.6323	.2488	.2952	.4407		
Herbicide	.4931	.3499	.2821	.3636	.3840	.3694	
Pesticide	.1489	.2574	.1032	.1268	-.0450	.0986	.0952

Table 31: Simple correlation among explanatory variables for rainfed rice production system

Transplanting rice in the spring season in rainfed area (n = 60)

	Yield	Manure	Nitrogen	Phosphorus	Potassium	Labour
Manure	.6384					
Nitrogen	-.3230	-.0854				
Phosphorus	.6039	.3624	-.1556			
Potassium	.4089	.3814	.0770	.3712		
Labor	.5633	.3356	-.2725	.4407	.4314	
Pesticide	.3993	.3336	-.0753	.4747	.4815	.4156

Transplanting rice in the summer season in rainfed area (n = 30)

	Yield	Manure	Nitrogen	Phosphorus	Potassium	Labour
Manure	.7341					
Nitrogen	.0860	.0075				
Phosphorus	.9041	.6586	.0424			
Potassium	.2363	-.1065	.2619	.0966	.1748	
Labour	.1656	.0283	.1217	.1774	-.3642	
Pesticide	-.1304	-.107	.0884	-.0993	-.2194	.2999

Broadcasting rice in the summer season in rainfed area (n=30)

	Yield	Manure	Nitrogen	Phospho	Potass	Labour	Herbic
Manure	.8028						
Nitrogen	.7507	.4560					
Phosphorus	.8164	.6488	.4882				
Potassium	.8037	.5703	.6784	.7503			
Labour	.9077	.7718	.6527	.7404	.7243		
Herbicide	.8888	.7350	.6847	.7275	.6640	.029	
Pesticide	-.4024	-.3348	-.3481	-.1718	-.2588	-.4948	-.3836

Furthermore, coefficient of determination (R^2) from the OLS regression is compared with correlation coefficient matrix of explanatory variables to decide whether the model has presence of severe multicollinearity. The results in Table 30a, 30b and Table 31 show that none of the correlation coefficients are found more than R^2, it considered that explanatory variables included in the model are free from the severe multicollinearity problem.

6.3.4. Ordinary Least Square estimates

The specified model for each production system is first estimated by OLS method. Breusch and Pagan's method is used to test heteroscedasticity again. The results indicate that there is no significant heteroscedaticity in all of production models. The scattered plot and curve estimates of each independent variable are checked for linear, quadratic, cubic and log. The linear form is the best for functional form. The result of OLS of seven production functions and the coefficients of the explanatory variables are discussed in detail in the following section.

6.3.4.1 OLS estimate of transplanting rice in the spring season in the irrigated area

The high value of R square and adjusted R square are high, 0.897 and 0.779 as show in Table 32 for the transplanting rice model in the spring season in irrigated region. This illustrate that the estimated function could be used to explain the variation of rice yield

The response of yield to manure, phosphorus, potassium and labor are positive and significant, implying that rice yield can be raised by using more of these inputs.

However, the costs of herbicide and nitrogen are not significantly different in this model. It can be explained that the level of nitrogen applied among the farmers does not vary and enough for maintaining rice yield.

Manure, phosphate, potassium and labour demonstrate a positive effect on rice yield. Phosphate, potassium, and labour coefficient are significant at the 95% confidence level for transplanting rice model in the spring season in the irrigated area. Therefore, 3.1, 2.3, 11.3, and 18.2 kilogram rice yield would be increased by additional one kilogram of nitrogen, phosphate, and potassium per sao and additional one manday per sao, respectively.

Table 32: OLS estimate of transplanting rice in the spring season in irrigated area

	Coefficient	T- value	Sign - T
ONE	-14.771745	-.276	.7834
Manure	.116656	1.700	.0951
Nitrogen	3.065756	.923	.3602
Phosphorus	2.297977	2.170	.0346
Potassium	11.338943	1.943	.0575
Labour	18.220936	2.092	.0413
Herbicide	.001639	1.473	.1468
Pesticide	-1.14848E-04	-.351	.7268
R- Square		.89738	
Adjusted-R square		.77907	
F- statistic		24.90599	
n =		60	

6.3.4.2. OLS estimate of transplanting rice in the summer season in irrigated area

The results in Table 33 reveal that R- square was equal 0.81, indicating that 81% of estimated function could be used to explain the effects of input use on rice yield. The cost of pesticide used per sao show a negative response to rice yield, but for transplanting rice in the spring season it is significantly different.

Table 33: OLS estimate of transplanting rice in the summer season in the irrigated are

	Coefficient	T value	Sign – T
ONE	33.042563	1.316	.1942
Manure	.152401	1.854	.0698
Nitrogen	3.470358	1.966	.0550
Phosphorus	3.126266	4.084	.0002
Potassium	6.049355	3.158	.0027
Labour	12.056524	2.670	.0103
Herbicide	1.57657E-04	.241	.8103
Pesticide	-8.524552E-04	-2.589	.0126
R- Squared		.81467	
Adjusted-R squared		.79249	
F- statistic		31.55184	
n =		60	

Except herbicide cost, all other inputs (manure, nitrogen, phosphate, potassium and labour) are highly significant. However, the response of rice yield to manure input is very small, about 0.15 kilogram rice yield would be increased by adding one kilogram of manure while 3.5, 3.1, 6.0 kilogram rice yield would be increased by adding one kilogram of nitrogen, phosphate and potassium per sao respectively. Adding one manday per sao also increase 12 kilogram rice yield.

6.3.4.3. OLS estimate of broadcasting rice in the spring season in irrigated area

Farmers in Thua Thien Hue province had been using the broadcasting rice method for the last five years. The facts that 4.4, 3.2, and 4.6 kilogram increase in rice yield by adding one kilogram of nitrogen, phosphate, potassium per sao respectively are illustrated in Table 34.

Table 34: OLS estimate of broadcasting rice in the spring season in irrigated area

	Coefficient	T value	Sign - T
ONE	-17.084552	-.413	.6812
Manure	.189678	3.369	.0014
Nitrogen	4.368552	1.760	.0845
Phosphorus	3.294877	3.043	.0037
Potassium	4.576819	1.744	.0871
Labour	5.814909	.809	.4225
Herbicide	.009418	2.301	.0255
Pesticide	-2.07525E-04	.510	.6122
R- Square		.74632	
Adjusted-R square		.71150	
F- statistic		21.43465	
n =		60	

Adding one man day would increase 5.8 kilogram of rice yield but it is not significantly different, whilst adding one kilogram of manure increases rice yield very little, but it is highly significantly different. Use of pesticides does not affect rice yield.

6.3.4.4. OLS estimate of broadcasting rice in summer season in the irrigated area

In the irrigated broadcasting rice in the summer season, result from Table 35 show that pesticide used per sao negatively affects rice yield. The coefficients of nitrogen, phosphate, potassium are around 4.1, 2.3, 2.0, respectively, these results show that farmers could use more nitrogen, phosphate, potassium to get higher rice

Table35: OLS estimates of broadcasting rice in summer season in irrigated area

	Coefficient	T value	Sign - T
ONE	45.243094	1.335	.1879
Manure	.207826	3.273	.0019
Nitrogen	4.110384	2.300	.0256
Phosphorus	2.338751	2.450	.0178
Potassium	2.046746	1.332	.1889
Labour	.304294	.056	.9555
Herbicide	.006685	2.225	.0305
Pesticide	-6.08449E-05	.173	.8635
R- Square		.71106	
Adjusted-R square		.66483	
F- statistic		16.15429	
n =		60	

yield per sao. The investigation of herbicide for broadcasting rice is significantly because chemical is the main method for weed control and weeding by hand is not easy for broadcasting rice. The R- square and adjusted R square are 0.71 and 0.66 illustrated that 71% of input factors could be used to explain the model.

6.3.4.5. OLS estimate of transplanting rice in spring season in rainfed area.

The result in Table 36 show that the inputs used for the transplanting rice with local rice varieties are able to explain yield variation up to 71 percent. The high R square value associated with the estimate indicates that the model is fitted well. Most of coefficients have positive values, indicating that farmers still could

Table 36: OLS estimates of transplanting rice in spring season in rainfed area

	Coefficient	T value	Sign-T
ONE	20.164267	.771	.4444
Manure	.261503	4.461	.0000
Nitrogen	-6.241654	-2.907	.0053
Phosphorus	3.771472	4.081	.0002
Potassium	3.198787	1.224	.2263
Labour	10.577148	2.754	.0061
Pesticide	-.001559	-1.644	.1068
R- Square		.71581	
Adjusted-R square		.68364	
F- statistic		22.24894	
n =		60	

increase productivity by additional use of inputs. The estimates in Table 36 also indicates the current rate of N fertilizer used by the farmers would not increase rice yield, as the local varieties having weak stems would lodge with high rate of N fertilizer. Use of pesticide would not also affect rice yield perhaps incidence of insect pest was not serious during the time study.

6.3.4.6. OLS estimate of transplanting rice in summer season in rainfed area.

The high value of R- square (0.89) associated with the estimates indicates that the model is fitted well. The use of pesticide was not affecting rice yield as shown by non-significant. In this model the coefficients of manure, nitrogen,

Table 37: OLS estimates of transplanting rice in summer season in rainfed area

	Coefficient	T value	Sign - T
ONE	13.786453	1.088	.2879
Manure	.115897	2.428	.0234
Nitrogen	3.661056	1.650	.1126
Phosphorus	5.070801	3.512	.0019
Potassium	2.424353	1.451	.1601
Labour	4.947891	1.963	.0619
Pesticide	-5.83064E-04	-.792	.4362
R- Square		.89082	
Adjusted-R square		.86233	
F- statistic		31.27547	
n =		30	

phosphate, potassium and labour are significantly positive, therefore, farmers could increase rice productivity by adding the above input factors. Results of Table 37 also illustrates adding one kilogram of phosphate would increase 5.1 kilogram rice per sao.

6.3.4.7. OLS estimate of broadcasting rice in the summer season in the rainfed area.

The significant level of variables are high excepted for manure, phosphate and herbicide. The small and positive coefficient of each variable indicates that

Table 38: OLS estimates of broadcasting rice in summer season in rainfed area

	Coefficients	T value	Sign - T
ONE	95.763135	5.454	.0000
Manure	.078029	2.243	.0353
Nitrogen	2.285866	2.320	.0300
Phosphorus	1.279674	1.991	.0590
Potassium	.928378	.472	.6415
Labour	2.082160	.576	.5703
Herbicide	.003235	2.231	.0362
Pesticide	-4.02786E-04	-1.247	.2256
R- Square		.92220	
Adjusted-R square		.89745	
F- statistic		37.25399	
n =		30	

adding one unit of input factors such as manure, nitrogen, phosphate, potassium as well as labour would increase little rice productivity. The R square value (0.92) showed that 92 % of all variables could be used to explain the model.

6.4. The optimization of input use.

Rice is primarily produced for home consumption, therefore farmers want to maximize productivity whilst minimizing the inputs. However, to evaluate the optimal use of inputs, farmers are assumed to achieve maximized profits.

The marginal product (MP) of a factor is defined as the increase in output resulting from one additional unit of factor. Assuming that a small change in v_1 (Δv_1) results in a change in output of Δq. We define the marginal product of v_1 (MP_1) as

$$MP_1 = \Delta q / \Delta v_1$$

Where q = output of product, and v_1 = input factor one

More formally we define $MP_1 = \delta q_1 / \delta v_1$ (Heath Fied and Soren Wibe, 1987)

Therefore, the coefficient of each significant input variable in the seven production functions can be used to calculate the physical marginal product and then, the marginal value of product is obtained by marginal product times output prices, this process can be expressed as follow:

$$MVP = P\,(MP) = P\,(\delta q / \delta v_n)$$

Where P = output price

Given that farmers wish to maximize profit, for them the optimal level of input use is attained where the marginal value of the product is equal to the unit cost of the input. The marginal product is the amount of output produced by the addition of one unit of input. Hence, the coefficients of each input derived from the production function can be used to calculate the MVP of the inputs. The marginal value of the product is equivalent to the coefficient of each input factor multiplied by the unit output price.

For example the marginal value of product for additional units of labour for transplanting rice in spring season in the irrigated lowland could be evaluated as follows:

MP lb	= 18.22	P= 1700 , P = price of output (VND)
MVlbP	= 18.22 * 1700 = 30974	
P(lb)	= 20000	
MVP/P(lb)	= 1.5	

The marginal value of labour is greater than the unit price of labour. This implies that farmers can still earn more income by adding labor.

6.4.1. The optimization of input use for transplanting rice in spring season in the irrigated area.

The value of MVP of most of the inputs in Table 39 for transplanting rice in spring season under the irrigated condition are greater than the input price except for herbicide. This mean that farmers can increase the input usage as long as the ratio MVP_{xi}/P_{xi} is above 1.

Table 39: Comparison of MVP to input prices of transplanting rice in spring season in irrigated area

Items	Manure	Nitrogen	Phosphorous	Potassium	Labour
MPP	0.12	3.07	2.30	11.34	18.22
MVP	204	5219	3910	19278	30974
Pxi	50	2500	1,000	2400	20000
MVP/Pxi	4.1	2.09	3.9	8.03	1.53

6.4.2. The optimization of input use for transplanting rice in summer season in the irrigated area.

In the case of transplanting rice in the summer season under the irrigated condition (Table 40), if using more manures and chemical fertilizers the value of returns will be more than their price. So farmers could still use manure, nitrogen, phosphorous and potassium to increase rice production.

Table 40: Comparison of MVP to input prices of transplanting rice in the summer season in irrigated area

Items	Manure	Nitrogen	Phosphorous	Potassium	Labour
MPP	0.15	3.47	3.12	6.04	12.05
MVP	255	5899	5304	10268	20485
Pxi	50	2500	1000	2400	20000
MVP/Pxi	5.1	2.4	5.3	4.3	1.0

6.4.3. The optimization of input use for broadcasting rice in the spring season in the irrigated area.

The ratios of MVP to unit price of labour and herbicide are less than one unit, therefore, farmers cannot invest more in their use to achieve higher rice production. The results from Table 41 show that inputs of more manure, nitrogen, phosphorous and potassium will continually increase rice production.

Table 41: Comparison of MVP to input prices of broadcasting rice in the spring season in irrigated area

Items	Manure	Nitrogen	Phosphorous	Potassium	Labour
MPP	0.19	4.37	3.30	4.58	5.81
MVP	323	7429	5610	7786	9877
Pxi	50	2500	1000	2400	20000
MVP/Pxi	6.4	2.9	5.6	3.2	0.5

6.4.4. The optimization of input use for broadcasting rice in summer season in the irrigated area.

Similarly in the case of broadcasting rice in the spring season, the ratios of MVP to unit price of manure, nitrogen, phosphorus and potassium are higher than their unit price, therefore, farmers could use more of these to increase rice production. (Table 42)

Table 42: Comparison of MVP to input prices of broadcasting rice in the summer season in irrigated area

Items	Manure	Nitrogen	Phosphorous	Potassium	Labour	Herbicide
MPP	0.20	4.11	2.33	2.05	0.30	0.0066
MVP	340	6987	3961	9569	510	11.22
Pxi	50	2500	1000	2400	20000	8169.4
MVP/Pxi	6.8	2.8	3.9	4.0	0.025	0.00

6.4.5. The optimization of input use for transplanting rice in the spring season in rainfed area.

For spring rice, farmers in the rainfed environment are planting local rice varieties, they are not spraying herbicide and nitrogen application give negative effect, hence, MVP of these inputs are not considered here. Manure, phosphorus and potassium are factors constraining rice production. This situation illustrates that to increase rice production farmers would have to use higher level of these factors.(Table 43).

Table 43: Comparison of MVP to input prices of transplanting rice in spring season in rainfed area

Items	Manure	Phosphorous	Potassium	Labour
MPP	0.26	3.77	3.20	10.57
MVP	442	6409	5440	17969
Pxi	50	1,000	2,400	20,000
MVP/Pxi	8.4	6.4	2.3	0.9

6.4.6. The optimization of input use for transplanting rice in the summer season in the rainfed area.

All types of fertilizers could be applied more to increase rice production because the results from Table 44 indicates that their MVP ratios to unit price are higher than one unit price. The results also show that the farmers could not increase rice productivity by investing more on human labour.

Table 44: Comparison of MVP to input prices of transplanting rice in summer season in rainfed area

Items	Manure	Nitrogen	Phosphorous	Potassium	Labour
MPP	0.12	3.66	5.07	2.42	4.94
MVP	204	6222	8619	4114	8398
Pxi	50	2,500	1,000	2,400	20,000
MVP/Pxi	4.1	2.5	8.6	1.7	0.41

6.4.7. The optimization of input use for broadcasting rice in summer season in the rainfed area.

In contrast to transplanting rice in the same production environment and planting season, the ratio of MVP to unit price of labour is less than one. All of the material inputs could increase rice production with the exception of potassium fertilizer. Hence, farmers will increase rice productivity by applying more manure, nitrogen and phosphorus.

Table 45: Comparison of MVP to input prices of broadcasting rice in the summer season in rainfed area

Items	Manure	Nitrogen	Phosphorous	Potassium	Labour	Herbicide
MPP	0.078	2.28	1.28	0.93	2.08	0.0032
MVP	132	3876	2176	1581	3536	5.44
Pxi	50	2,500	1,000	2,400	20,000	7,952.6
MVP/Pxi	2.6	1.6	2.1	0.65	0.18	6.8