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Technical efficiency of irrigated rice farming in northern Philippines

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Key words: Technical efficiency, Irrigated rice, Productivity, Stochastic frontier analysis.

Abstract

Despite rice technology breakthroughs, the past year's average yield in irrigated rice both in the wet and dry season is considerably low where Cagayan province, Philippines lagging behind compared to rice producing province counterparts. This study was conducted to analyse the factors associated on technical efficacy of irrigated rice farming in the northern Philippines. It made use of correlational design, covered two farming ecosystem. Nine (9) municipalities and eighteen (18) barangays were chosen considering the top three, middle three and the lowest three rice producing municipalities with a total of 393 respondents. Stratified random sampling, Slovins formula and a semi-structured survey questionnaire were used. The Stochastic Frontier Analysis (SFA) was a tool used in the analysis of data to determine the factors influencing productivity. Factors like socio-economic profile, cultural management, climatic and environmental, support services, issues and constraints were considered to have effect to irrigated rice productivity. Stochastic Frontier Analysis results showed that only few of the top 3, middle 3 and bottom 3 irrigated rice farmers are production efficient both in the wet season of 2013 and dry season of 2014 farm operation. Proper timing of planting, government support price to boost production and farmers should slowly convert their farms into organic to improve production efficiency are recommendations to address their most pressing problems.

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Introduction

Land is a key factor in production agriculture and the land rental market is an important institution in agriculture. Agriculture is main source of income in developing countries and increased agricultural productivity has the potential to alleviate poverty of the farmers. Improvements in agricultural productivity are a topic of high importance in these countries (Koirala *et al.,* 2014).

Rice self-sufficiency has been the focus of Philippine rice programs. Self-sufficiency results from locally producing an adequate volume of rice for food and other uses. Despite being the eighth largest rice producer in the world, the Philippines is not on the list of top rice yielders (FAO Statistical Yearbook, 2013). This indicates that the country's rice area is not yet producing its maximum quantity of harvested rice per hectare, compared to other rice-producing countries. It has 4.5 million hectares rice area harvested that produce 16.7 million tons of rice (FAO Statistics, 2005-2014). These correspond to an average of 3.75t ha-1 national yield level, which is lower than the average yields of other Asian countries such as China (6.56), Indonesia (4.92) and Vietnam (5.31).

Cagayan Province lies in the northeastern part of mainland Luzon, Philippines occupying the lower basin of the Cagayan River. It has a total land area of 900, 270 hectares including Babuyan Island which constitutes 3% of the total land area of the Philippines. From the total land of the province, 17.76% is classified as agricultural land.

About 94,470 hectares of irrigated land in Cagayan are planted with rice. Its average yield is 4.18MT/hectare during dry season for irrigated land and 3.84MT /hectare during wet season. The combined rice productivity in Cagayan Valley Region is 4.2MT/hectare making it the 2nd largest rice producer in the Philippines.

However, in 2014, Cagayan province only placed no. 4 in the Top Ten Rice producing provinces in the Philippines with a total rice yield of 895, 580 metric tons. With this drastic decrease in the rice yield of Cagayan province, there is a dire need to look into the technical efficiency of irrigated rice production in Cagayan Province.

On the production side growth and development of rice production have become completely dependent on yield improvements. To meet demand, rice production can be increased either by increasing rice growing area or by improving the efficiency of existing resources allocated to rice production. Yield improvement is governed mainly in two ways; either shifting the yield frontier or by developing and promoting yield-enhancing technologies. Improving rice productivity can contribute to higher yield and in reducing poverty especially in rural areas, increased productivity may also help in increasing the income and food security of small farmers, who depend on rice production for a living. Irrigation, adoption of hybrid and third generation modern inbred rice varieties, training at farmer's level, use of high quality seed, and use of modern agricultural tools can boost rice production in the Philippines (Bordey, 2010).

The aim of this study was to analyse the factors associated on technical efficacy of irrigated rice production in the northern Philippines using Stochastic Frontier Analysis. The study will be a basis for policy recommendations for organic rice production in the region.

Materials and methods

Research Design

This research study made use of correlational design to determine the degree of relationship of variables. As well as to analyse the factors associated on technical efficacy of irrigated rice production in the northern Philippines.

Research Areas

The study considered the irrigated rice during wet season of 2013 and dry season of 2014. Municipalities were chosen considering the top three, middle three and the lowest three rice producers in the past five years (DA-PLGU and RFO2, 2014). From these nine municipalities, three barangays with the biggest rice land area per municipality were taken as actual study sites.

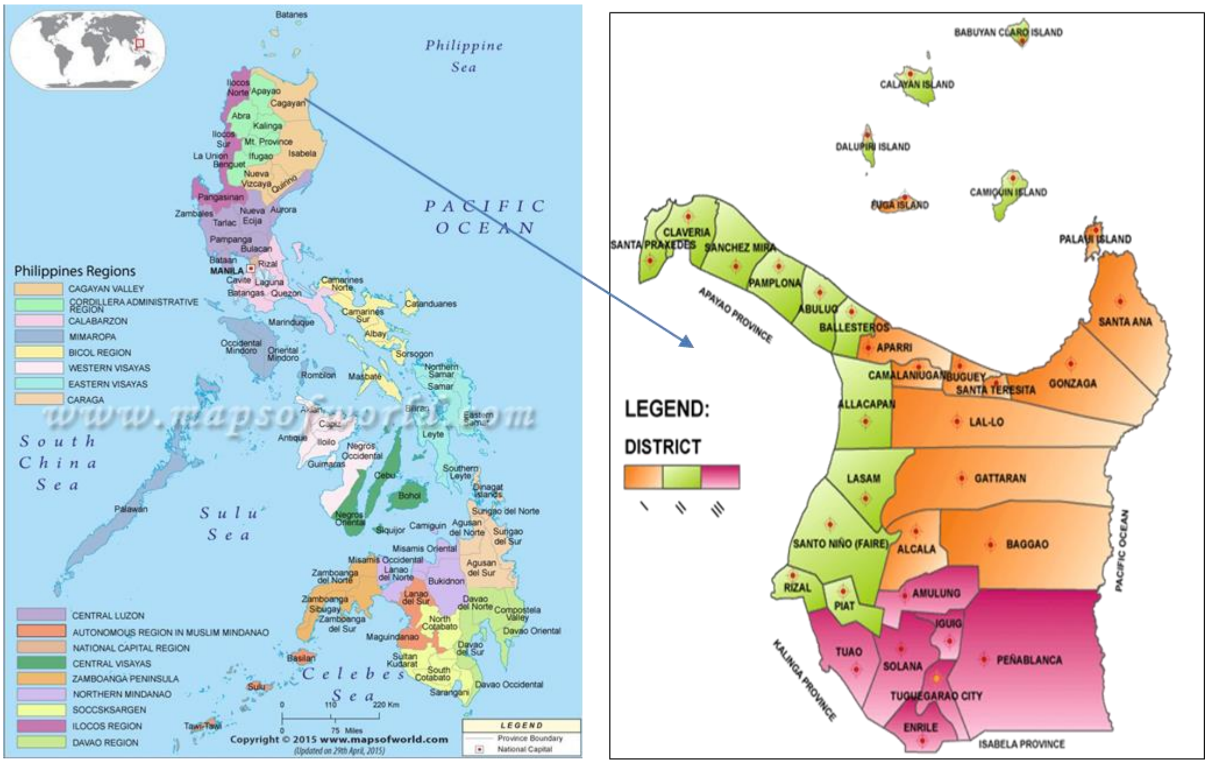

Fig. 1. Map of the Philippines showing the Province of Cagayan as sites of the study.

Population and Sample Size

Criteria in choosing the town and number of farmer respondents per area included the recorded production for the last two seasons of 2013 based on hectarage, volume, and average yield level, and the number of rice farmers in the municipality. The stratified random sampling was used, as shown below, to get the proportional number of respondents from sub-populations across three farmer group categories. Sample sizes were determined using Slovins formula with a margin of error at 5%. Actual respondents were chosen by purposive stratified random sampling technique.

Table 1. Selected Rice Producing Municipalities and Number of Respondents for Cagayan Province.

			Cagayan province			
Ecosystem	Municipality	Hectarage	Volume (tons)	Average Yield (tons/ha)	Total No. of Farmers	Sample Size
Irrigated						
	Lal-lo	784.271	3570.4305	4.55	605	11
Top 3	Lasam	2 Solana448.52	10504.1508	4.29	1142	20
	Tuao	3,552.7	15,170.29	4.27	5773	99
	Solana	12715.55	52515.2215	4.13	5996	103
Middle 3	Gattaran	910535.42	375404.2	4.12	4354	75
	Penablanca	1303.83	5332.66	4.09	1539	27
	Iguig	968.4067	3399.107517	3.51	1188	20
Bottom 3	Ballesteros	2740.32	10632.4416	3.88	1562	27
	Sta. Praxedes	367.31	1395.778	3.80	596	11
Total Irrigated					22,757	393

$$n = \frac{N}{1+Ne2} \text{ and } ni = \frac{Ni}{N} \times n$$

where: n = sample size by Slovin's Formula

e = error margin (0.05)

n_i= sub-sample

N= total number of farmers in selected towns

N_i= sub-population per municipality

Research Instrument

A semi-structured survey questionnaire was designed as a primary tool in gathering data.

The instrument captured: 1) socio-demographic profile, 2) factors influencing rice productivity, and 3) issues and constraints encountered and recommended solutions by rice farmers in Cagayan Valley.

Data Collection and Analysis

Enumerators and data encoders were hired to handle the survey and data collection. Enumerators were briefed and oriented on the different items asked from the respondents. Data were collected through personal interview to ensure the validity and accuracy of data gathered and to minimize validation of data. Data gathering was complemented with actual observations and documentation. Secondary data needed in the study was secured from files and reports of concerned agencies. Researchers convened the enumerators every end of the day to evaluate the completeness and veracity of data gathered and to address problems and issues encountered in the course of data gathering.

Stochastic Frontier Analysis (SFA)

SFA as shown below is an economic analysis tool used to evaluate technical efficiency of irrigated rice farming in Cagayan province. The output /yield as the dependent variable correlated with factors as independent variables. Frontier production functions are important for the prediction of technical efficiencies of individual firms in an industry (Batese & Coelli, 1992).

Model 1 (Gujarati 1999).

$$y = x_i b + e_i$$

where: y = yield per hectare

x_i = columns of inputs (labor, fertilizers, etc)

b = are series of parameters to be tested at 5% level

e_i = the "stochastic random error representing the influence of other variables or randomness of human behavior that cannot be totally predicted" (Gujarati 1999).

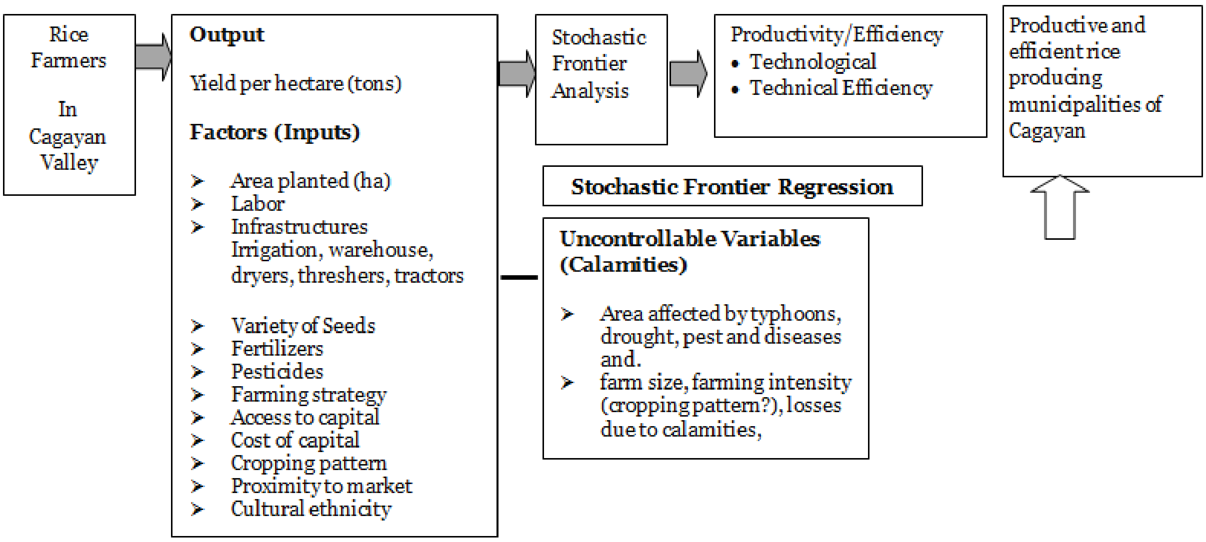

Fig. 2. The SFA framework for evaluating technical efficiency of irrigated rice farming in Cagayan province.

Model 2 (Battese and Coelli 1995)

$$y = x_i b_i + (v_i - u_{it})$$

where: y = is the yield per ha in Ln

x_i = inputs as specified elsewhere

b_i = parameters tested at 5% level

v_i = are random variables which are assumed to be *iid* (independent and identically distributed) truncated normal with zero mean and variance $[N(0,\sigma_v^2)]$, and independent of the technical inefficiency (Ui), (Coelli 1996). It is commonly known as e_i in the classical econometrics or the "stochastic random error representing the influence of other variables or randomness of human behavior that cannot be totally predicted (Gujarati 1999).

U_{it} = which are non-negative random variables which are assumed to account for technical inefficiency in the rice farmers' activities and are assumed to be independently distributed (iid) as truncations at zero of the N(m_{it},σ_U^2) distribution; (Coelli 1996)."

$U_{it} = d_i Z_{it}$, i = 1, ...N t = 1, ..., 2

where:

Z_{it} are dummy variables which may influence the farming efficiency of region 2 farmers, expressed as:example

Z_1 = ownership: 1 = if owned farmland and 0 = if not

Z_2 = farming intensity, 1 = if cropping is > 1, 0 = if cropping is 1 only

Z_3 = calamities, in million pesos

d_i = are parameters to be estimated and tested at 5% level

Results and discussion

Table 1. Farmers' profile in rice irrigated areas in Cagayan Province.

Item	Top 3	Middle 3	Bottom 3
Average Age (years)	49.8	50.4	50.2
Sex (% male)	69.2	80.3	77.2
Average Household size	4.7	4.8	4.9
Average Education (years)	7.6	7.1	7.6
Land Owner	79.2	58.7	63.2
Average Number of years in farming	22.0	23.6	22.4
Average Area Cultivated	2.64	1.8	1.8
Rice production training (%with training)	49.2	19.7	56.2
Membership in Organization (% member)			

Results of Stochastic Frontier Analysis as presented in table 2 shows that farm financing has an inverse significant relationship to yield among top 3 yielding municipalities. Any increase in the loan availed caused a corresponding decrease to yield by 35.425 cavans per hectare. While the cost on random planting practice has a high significant relationship to yield which causes an increase in yield in cavan by 53.624 per hectare. Any increase per unit volume of irrigation water supply, cause a corresponding increase of 37.947 cavan in yield per hectare.

Among middle 3 yield performing municipalities, their tenurial status as owners has an inverse significant relationship to yield. As they increase their ownership of land per hectare, they tend to decrease their yield by 16.093 cavans. As they increase their loan in peso, their yield increases by 15.465 cavans. As they increase the area they cultivate in flat topography, their yield in cavans is reduced by 21.262 per hectare. The distance of their farm is inversely related to yield, the farther the distance of their farm to the road, the lower is their yield in cavans by 15.92. As the climatic condition is unfavourable like flood and drought, their yield decreases by 6.361 cavans per hectare. Any increase per unit of their hybrid seed for planting, their yield in cavan increases by 23.136. As they employ mechanized land preparation, their yield increases by 2.642 cavans. Using NIA sourced unsustained irrigation water decreases their yield by 25.615. Manual harvesting decreases their yield by 3.239 cavans while mechanized threshing reduced their yield by 5.316.

The Bottom 3 irrigated rice farmer respondents usually borrow money for their farm operation which has an inverse significant relationship to their yield. As the amount of loan increases, yield in cavans decreases by 20.255. The distance and type of market road to their farm has a high significant effect to yield, the nearer the market road to their farm, their yield in cavans increases by 22.5. Unfavorable climatic condition has an inverse significant effect to yield. The more incidence of drought and floods results an adverse effect to the yield by 12.012 cavans. Any increase per unit of hybrid rice seed variety, a corresponding increase in yield by 16.594 cavans is derived. An increase in the cost of seedbed preparation employing wetbed method has a negative effect to yield by 5.046 cavans. Likewise an increase in the cost of random planting method reduced yield by 14.798 cavans. Sufficient irrigation water sourced out from NIA caused an increase in yield by 8.435 cavans. Increasing cost on pest/disease management using chemicals reduced yield by 9.97 cavans. While an increase in the cost of manual harvesting decrease yield by 9.953. Mechanized threshing increases yield by 2.635 cavans. Harvesting rice crops within the maturity date increases yield by 14.307 cavans. Selling the products to traders increases yield in cavans by 13.907 and selling rice produced in dry form increases yield by 13.107cavans per hectare.

Table 2. Stochastic Frontier Analysis Summary of the Top 3, Middle 3 and Bottom 3 Yielding irrigated rice farming municipalities in Cagayan province during the wet season of 2013.

Parameters	Variables	Coef	t-ratio	Coef	t-ratio	Coef	t-ratio
		Top 3 YM		Middle 3 YM		Bottom 3 YM	
Bo		-29.57	-30.11**	457.48	467.24**	-1607.16	-1619.49**
b1	Quantity of fertilizer	-17.54	-26.45**	107.78	179.28**	-91.87	-127.04**
b2	Quantity of seeds	-44.65	-33.51**	-0.32	-0.89ns	-9.06	-13.07**
b3	Quantity of labor	32.66	32.27**	9.32	21.78**	-225.82	-349.81**
b4	Cost of labor	-32.60	-32.67**	-107.82	-179.85**	91.88	144.22**
b5	Cost of pesticides	0.09	3.42**	0.42	1.23ns	9.02	13.30**
b6	Cost of farm services	0.01	0.25ns	-9.43	-22.01**	225.98	372.68**
b7	Cost of seeds	44.69	33.39**	-0.02	-0.40ns	0.31	1.46ns
b8	Cost of fertilizer	17.53	26.44**	-0.02	-0.64ns	-0.09	-0.30ns
do		0.79	1.10ns	0.78	0.90ns	0.21	0.21ns
d1	Age	0.00	1.40ns	0.01	0.88ns	-0.03	-0.71ns
d2	Household size	0.00	-0.52ns	-0.01	-0.22ns	0.06	0.33ns
d3	Sex	-0.04	-1.25ns	-0.43	-2.68**	0.06	0.07ns
d4	Educational Attainment	0.02	0.37ns	0.07	0.46ns	1.07	1.55ns
d5	Years in farming	0.00	-0.36ns	0.00	-0.40ns	0.04	1.86ns
d6	technical assistance	-0.02	-0.61ns	0.08	0.37ns	0.16	0.22ns
d7	Household HI	0.00	-27.91**	0.00	-0.47ns	0.00	0.43ns
d8	Tenurial Status	-0.02	-0.52ns	-0.03	-0.19ns	-0.32	-0.54ns
d9	Area	0.00	0.20ns	-0.58	-4.84**	0.08	0.51ns
d10	Capita	0.00	-0.67ns	0.00	-0.41ns	0.00	-2.75**
d11	Water Source (NIA)	-0.03	-0.97ns	1.24	3.22**	-0.19	-0.19ns
d12	Topography	0.01	0.24ns	-0.25	-1.88*	0.21	0.21ns
d13	Soil Type (Clay)	0.79	1.10ns	0.02	0.16ns	-0.21	-0.32ns
d14	Variety Of Seed (inbred)	0.07	1.30ns	-0.20	-1.60ns	0.09	0.12ns
d15	Land Preparation (Combined)	0.06	1.25ns	-0.10	-0.44ns	0.00	0.00ns
d16	Pest and Disease Control (Chemical)	-0.03	-0.56ns	-0.04	-0.08ns	-0.33	-0.48ns
d17	Harvesting (Manual)	0.05	0.65ns	-0.57	-2.27*	-0.07	-0.09ns
d18	Cropping Practice (Mono)	0.02	0.25ns	0.25	1.63ns	-0.32	-0.37ns
d19	Fertilizer application (inorganic)	0.02	0.27ns	0.16	0.69ns	1.30	1.48ns
d20	Insecticide application (chemical)	0.05	0.85	0.14	0.56ns	0.00	0.00ns
d21	Weeding (chemical)	-0.01	-0.39	0.06	0.43ns	-0.22	-0.44ns
d22	Foliar fertilizer	-0.02	-0.51	-0.02	-0.15ns	0.01	0.02ns
d23	Type of FMR	-0.06	-1.87	-0.11	-0.73ns	-0.30	-0.40ns
d24	Distance of FMR (less than 1km)	0.06	1.26	-0.11	-0.81ns	0.70	0.99ns
d25	Random planting	0.06	1.20	-0.10	-0.69ns	0.11	0.15ns
sigma-squared		0.01	8.02	0.21	5.67**	0.27	2.1742220*
gamma		0.72	17.65	0.85	13.80**	0.54	3.1611542**

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In the dry season 2014 farm operation, the Top 3 yielding irrigated rice farmer respondents as influenced by different factors is depicted in table 3. As the farmer respondents increase their loan in peso, a decrease in their yield by 42.484 cavans is derived. While as they increase their farm operation in a flat farm topography in hectare, their yield increases by 4.491 cavans. The farther their farm to market road, their yield decreases by 6.162, Favorable climactic condition increases yield by 17.332 cavans. Increasing the use of inbred seed variety cause an inverse high significant effect to yield by 58.502 cavans. Increasing cost on mechanized land preparation decreases yield by 6.059 cavans. Increasing cost on seedbed preparation employing wetbed decreases yield by 3.315 cavans. Planting practice employing random increases yield by 20.247 cavans. Sufficient irrigation water supply sourced out from NIA has a high positive significant effect to yield by 36.882 cavans. Increasing cost in chemical pest/disease management increases yield by 10.824. Increasing manual harvesting costs, significantly decrease yield by 17.792. Increasing cost in mechanized threshing decreases yield by 11.779 cavans. Harvesting within the maturity date increases yield by 4.187 cavans. Selling products to traders increases yield by 9.314 while selling as dry form decreases yield by 39.456.

As the middle 3 yield performing municipalities increase their land ownership and tilling of land per hectare, their yield decreases by 16.051 cavans. While as they increase their land to till in flat topography, their yield increases by 5.9233 cavans. The farther their farm to market road in kilometers, their yield decreases by 10.476 cavans. As unfavorable climatic condition often hit their crops, their yield decreases by 6.961 cavans. As they increase their use of hybrid seed variety to plant, their yield increases by 15.048. As they increase their cost in mechanized land preparation, yield decreases by 9.848. Employing wetbed method in their seedbed preparation cause an increase in yield by 4.99 cavans. Likewise employing random planting practice increases yield by 24.879 per hectare. Increasing cost on the use of inorganic fertilizer decreases yield by 16.295 per hectare. Meanwhile sufficient water supply sourced out from NIA increases yield by 13.908 cavans. But increasing cost on chemical pest/disease management decreases yield by 8.282 cavans. Increasing manual harvesting cost, decreases yield by 17.391. Harvesting crops beyond maturity date decreases yield by 2.004. As they sell products to traders, their yield decreases by 2.646 but selling in dry form increases yield by 10.539 cavans.

While as the Bottom 3 irrigated rice farmer respondents during the dry season of 2014 increases their land ownership to till, their yield increases by 30.134cavans. The farther the distance of their farm to the market road, their yield decreases by 90.079 cavans. While seedbed preparation employing wetbed method increases yield by 57.597 cavans. Random planting method increases yield by 57.597 cavans. Increasing cost on inorganic fertilizer decreases yield by 34.165 cavans per hectare. Insufficient water supply from NIA causes a decrease in yield by 68,481 cavans. Increasing cost on the chemical pest and disease control management decreases yield by 139.627 cavans. Increasing cost on manual harvesting decrease yield by 41.611. Increasing cost on mechanized threshing decreases yield by 59.233. Harvesting beyond maturity date decreases yield by 49.478 cavans. Selling products to traders decreases yield by 16.744 cavans and selling products in dry form decreases yield by 33.355 cavans.

Table 2. Stochastic Frontier Analysis summary of the Top 3, Middle 3 and Bottom 3 irrigated rice farming municipalities of Cagayan province during the dry season of 2014.

Parameters	Variables	Coef	t-ratio	Coef	t-ratio	Coef	t-ratio
		Top 3 YM		Middle 3 YM		Bottom 3 YM	
Bo		-30.31	-4.18**	18.72	18.97**	2456.92	2465.85**
b1	Quantity of fertilizer	-1.44	-6.87**	0.57	2.81**	0.34	0.41ns
b2	Quantity of seeds	-0.17	-1.06ns	0.36	2.12*	-100.66	-114.54**
b3	Quantity of labor	-0.14	-0.55ns	0.00	0.01ns	499.47	595.34**
b4	Cost of labor	6.92	4.36*	-2.13	-2.64**	-0.16	-0.17ns
b5	Cost of pesticides	1.76	2.11*	-0.84	-0.91ns	100.97	147.18**
b6	Cost of farm services	0.40	0.62ns	0.07	0.34ns	-498.91	-634.46**
b7	Cost of seeds	-0.01	-0.65ns	0.01	0.42ns	0.10	0.40ns
b8	Cost of fertilizer	0.04	1.86ns	-0.02	-0.68ns	0.00	-0.02ns
do		1.91	2.00ns	-0.16	-0.17ns	-0.07	-0.07ns
d1	Age	0.00	-0.22ns	-0.01	-0.29ns	0.05	0.88ns
d2	Household size	0.00	0.07ns	0.05	0.48ns	-0.09	-0.23ns
d3	Sex	0.25	1.12ns	0.00	0.00ns	-0.13	-0.12ns
d4	Educational Attainment	-0.02	-0.23ns	-0.23	-0.38ns	0.00	0.00ns
d5	Yrsfarming	0.01	1.19ns	0.02	1.12ns	-0.02	-0.47ns
d6	technical assistance	-0.09	-0.33ns	0.57	1.16ns	-0.12	-0.12ns
d7	HHI	0.00	-8.62**	0.00	-2.26*	0.00	-0.70**
d8	Tenurial Status	0.06	0.24ns	-0.20	-0.43ns	-0.04	-0.04ns
d9	Area	0.00	0.06ns	0.07	0.77ns	0.11	0.27ns
d10	Capita	0.00	-0.29ns	0.00	0.26ns	0.00	-0.36ns
d11	Water Source (NIA)	-0.58	-0.74ns	-0.76	-0.74ns	-0.07	-0.07ns
d12	Topography	-0.68	-2.69**	0.54	1.04ns	0.06	0.06**
d13	Soil Type (Clay)	0.16	0.59ns	-0.50	-0.61ns	0.10	0.10ns
d14	Variety Of Seed (inbred)	-0.02	-0.12ns	0.00	0.00ns	0.02	0.02ns
d15	Land Preparation (Combined)	0.60	2.96**	-1.11	-1.56*	0.01	0.01**
d16	Pest and Disease Control (Chemical)	-0.52	-0.67ns	0.15	0.15ns	-0.05	-0.05ns
d17	Harvesting (Manual)	-0.05	-0.23ns	-0.33	-0.49ns	0.05	0.05ns

Parameters	Variables	Coef	t-ratio	Coef	t-ratio	Coef	t-ratio
		Top 3 YM		Middle 3 YM		Bottom 3 YM	
d18	Cropping Practice (Mono)	0.04	0.11ns	-0.27	-0.42ns	0.00	0.00ns
d19	Fertilizer application (inorganic)	0.49	1.02ns	-0.72	-1.00ns	-0.11	-0.11ns
d20	Insecticide application (chemical)	-0.08	-0.95ns	0.27	0.40ns	-0.01	-0.01ns
d21	Weeding (chemical)	-0.23	-1.00ns	0.22	0.36ns	-0.06	-0.06ns
d22	Foliar fertilizer	0.00	0.00ns	0.21	0.37ns	-0.05	-0.05ns
d23	Type of FMR	0.04	0.31ns	0.55	1.06ns	0.15	0.15ns
d24	Distance of FMR (less than 1km)	-0.04	-0.79ns	0.33	1.08ns	0.03	0.03ns
d25	Random planting	-0.21	-5.49*	-0.25	-0.35ns	-0.18	-0.16*
sigma-squared		0.25	7.046*	0.39	5.08**	1.44	1.56*
gamma		1.00	2023153.8	0.94	48.45**	1.00	51712.52**

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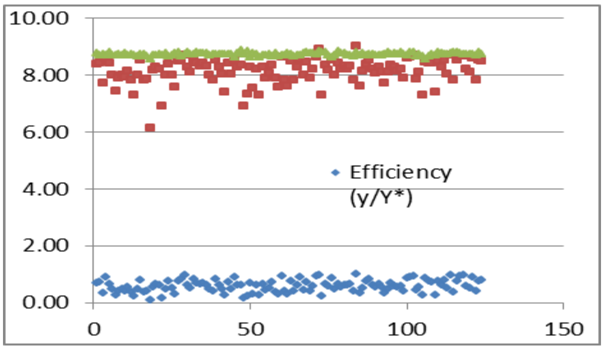
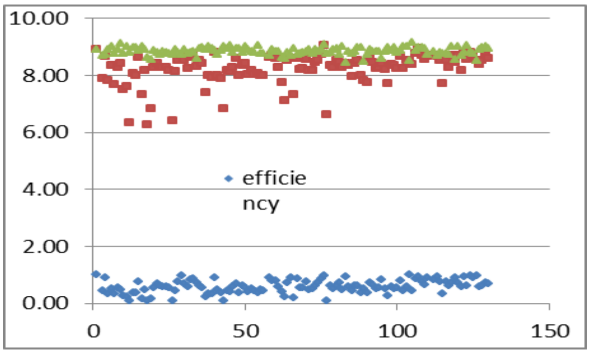
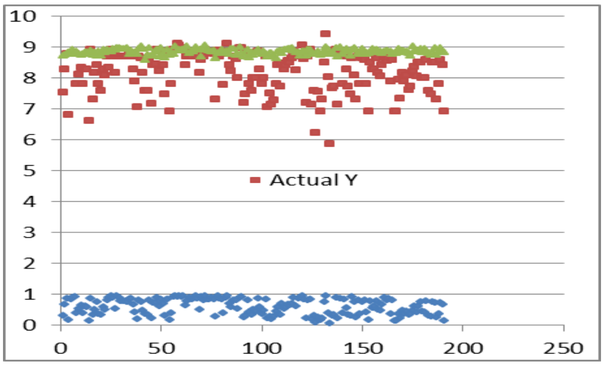


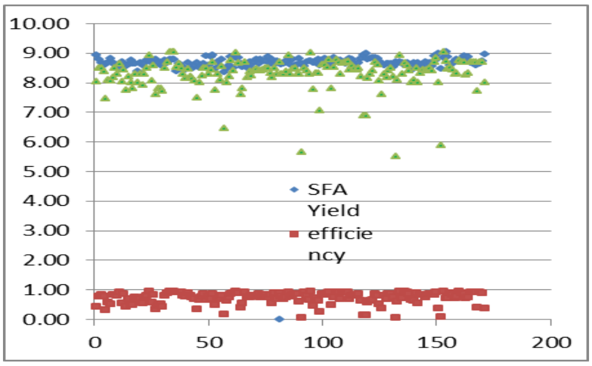
Wet Season Dry Season



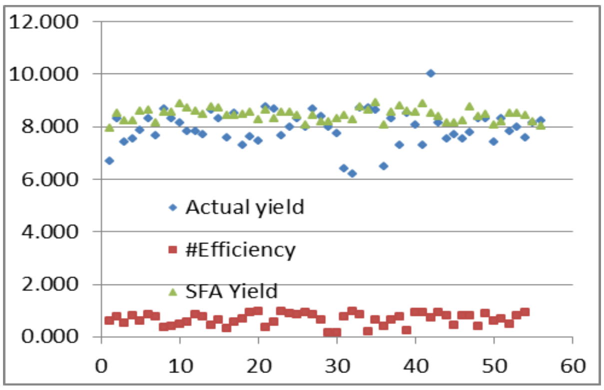
Top 3 Yielding Municipalities



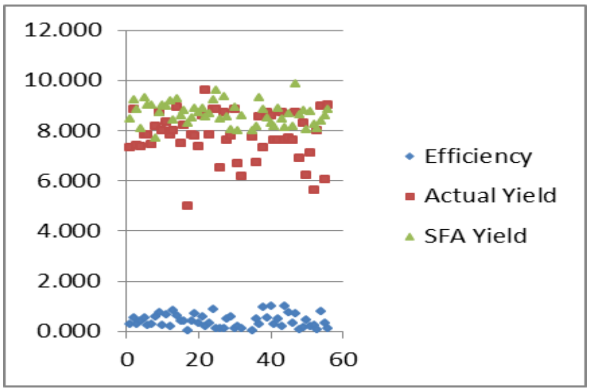
Middle 3 Yielding Municipalities



Wet Season Dry Season



Bottom 3 Yielding Municipalities



Wet Season Dry Season

Fig. 3. Stochastic frontier lines of the Top 3, Middle 3 and Bottom 3 Yielding Municipalities during the wet season of 2013 and dry season of 2014.

Fig. 1 shows the frontier line indicating the standard level of yield and the actual yield generated by irrigated rice farmers during the wet season of 2013. As the farmer exceeds the frontier yield line as indicated by the actual yield line, such farmers are production efficient. It is evident to note that only few Top 3 irrigated rice farmers during the wet season of 2013 and dry season of 2014 farm operation are production inefficient.

While to the middle 3 irrigated rice yielding municipalities, illustrations show that most of the Middle 3 irrigated rice farmers are production efficient in their wet season farm operation in 2013. Most of the actual yield points of the Middle 3 irrigated rice farmer respondents fall below the frontier line. This means that their production fall below the standard production level or frontier line.

It is very evident to note that almost all the Bottom 3 irrigated rice farmer respondents are production inefficient in their 2013 wet season operation. Almost all the points in the frontier line indicating standard measure of individual farmer production fall below the actual yield line. Almost all the Bottom 3 irrigated farmer respondents are production inefficient in their dry season 2014 farm operation. This is obviously supported by the inverse high significant effects of different variables to yield presented in table 2 and 3.

Conclusion

In light of the findings, the following conclusions are hereby drawn:

1. The Stochastic Frontier Analysis results show that farm financing has an inverse significant relationship to yield. The cost on random planting practice and increase in the volume of irrigation water has high significant relationship to yield. The SFA graph shows that only few Top 3 irrigated rice farmers during the wet season of 2013 farm operation are production efficient.

2. The tenurial status of farmers as owners, distance of farm to market road, unfavourable climatic condition, unsustained irrigation water, manual harvesting, mechanized threshing and increasing their area cultivated on flat farm topography have an inverse significant relationship to yield. Any increase per unit of their hybrid seed and employing mechanized land preparation, increases yield during the wet season farm operation. SFA illustration shows that most of the Middle 3 irrigated rice farmers are production inefficient in their wet season farm operation in 2013.

3. The increase in the borrowing of money, unfavourable climatic condition, cost of seedbed preparation, cost of random transplanting method, cost on disease/pest management, cost of manual harvesting among Bottom 3 irrigated rice farmer respondents have an inverse significant relationship to their yield. The distance and type of market road to their farm, increase in hybrid seed variety, sufficient water supply from NIA, harvesting rice crops within the maturity period and selling dry products to traders have a high significant effect to yield. Almost all the Bottom 3 irrigated rice farmer respondents are production inefficient in their 2013 wet season operation.

4. The increase in the loan in peso, distance of their farm to market road, increasing hybrid seed variety used, cost of mechanized land preparation, cost of seedbed preparation, by the farmer respondents, cost of manual harvesting, cost of mechanized threshing and selling products in dry form cause a decrease in yield. While the increase of farm operation in a flat farm topography in hectare, favourable climatic condition, random transplanting, sufficient irrigation water supply, cost in chemical pest/disease management increase yield.

5. Increasing manual harvesting costs and selling products to traders increase yield. The Stochastic Frontier Analysis graph of the Top 3 irrigated rice farmer respondents indicates that they are production inefficient in their dry season 2014 farm operation.

6. The increase in the ownership of land to till by the respondents, longer distance of farm to market road, unfavorable climatic condition, cost of mechanized land preparation, cost of pest/disease control, cost of manual harvesting, harvesting beyond maturity and selling products to traders decreases yield. While the increase of land to till in flat topography, increase in

the use of hybrid seed per unit, employing wetbed method, sufficient irrigation water supply increases yield. The Middle 3 irrigated rice farmer respondents are production inefficient.

7. As the Bottom 3 irrigated rice farmer respondents increases their land ownership to till, cost of seedbed preparation, cost of random transplanting, their yield increases. While farther distance of farm to market road, increase cost of inorganic fertilizer, Insufficient irrigation water supply, increasing cost on the chemical pest and disease control management, Increasing cost on manual harvesting, increasing cost on mechanized threshing, harvesting beyond maturity date decreases yield. Almost all the Bottom 3 irrigated farmer respondents are production inefficient in their dry season 2014 farm operation.

Recommendations

This study recommends the following: (1) Proper timing of planting should be observed to minimize crop devastation due to floods, drought and cold spill and to have sufficient supply of irrigation water from NIA; (2) Increasing the use of inorganic fertilizer and chemical based pest and disease control causes significant decrease in yield, hence making farmers production inefficient. Farmers should slowly convert their farms into organic to improve production efficiency.

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