Cover

Total factor productivity in the INTA Chinandega rice variety

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Abstract

The study focused on measuring the impact of the INTA-Chinandega rice variety on the rate of production increase in 40 farms in the North Pacific region of Nicaragua. Data from INTA Pacific North was used and covered the 7 production cycles. The DEA approach was used as a non-parametric programming method to calculate the Malmquist productivity indices. The results showed that the INTA Chinandega variety had a 1% impact on the average rate of change of TFP. The possible causes of this variability are due to the rate of change in technical efficiency rather than due to INTA Chinandega technology. In the municipality of El Viejo, TFP reached a maximum of 13% year-on-year.

JEL Classification: O: 32; Q: 16; D: 24

Keywords: Data Panel; Envelope Data Analysis; INTA-Chinandega Technology; Total factor productivity growth; Malmquist index

1 Introducción

The study focused on studying the farms that adopted rice technology, during the 2003-2009 production cycles, at the level of the North Pacific region of Nicaragua, to estimate the variation in the growth of total factor productivity (TFP) from the INTA Chinandega rice variety. The rate of growth of the productivity of the farms in Nicaragua has been a concern of the producers and other local actors organized in the municipal production institutions, the National Institute of Agricultural Technology (INTA), as the main actor in the transfer of technology in the country, highlights this concern. Academic research that contributes in this direction has been a concern of the academy and INTA researchers. In Nicaragua, there are few studies that have been directed on this subject, however, this topic has been the subject of intensive research at the international level in recent decades for researchers, so we can mention that during the years 1980 and 2015 a number of main Cross-country analysis has been developed to investigate agricultural productivity (Coelli and Rao 2005, Zuniga-González 2011, Dios-Palomares et al. 2015).

These studies have mostly used cross-sectional data in approximately 40 countries to estimate the Coob Douglas technological production function using regression methods. Focused on estimating production elasticities and academic research on the contributions of production to scale, education, and research on explaining productivity differences across countries, others do so by region within the country. Similarly, research work has been carried out at the Bravo-Ureta region level, & Evenson (1994), Bravo-Ureta et al. (2007).

INTA has developed a variety of rice called INTA Chinandega, in such a way that this Technology (INTA Chinandega) is part of the effort of the National Institute of Agricultural Technology (INTA) whose objective is to transfer technologies to producers by providing a variety of rice seeds resistant to climate change, including the INTA Chinandega variety, the object of our study. The relevance of this effort focused on validating and observing the variability of the change to increase the productivity growth of rice-producing farms aimed at satisfying the demand for this item in relation to population growth, since currently Nicaragua, we are not self-sustaining , and we depend on imports. During the period 2002 to 2005, the external dependency index increased from 42% to 58.2%, decreasing for the year 2007 to 41.2%, a similar situation for the years 2010 to 2020 and the tendency is to decrease for the year 2021 with the measures of the Government of Reconciliation and National Unity (GRUN), in this context, it is important to investigate the variability of the productivity growth of the INTA Chinandega variety (Rivas 2008, Zuniga 2020).

INTA Chinandega was the result of a technological validation offered by INTA, it is identified as a variety of rice (*Oryza sativa L*) Precocious for dry conditions in adverse weather conditions. The INTA Chinandega variety comes from the VIOFLAR 1997 of the Rice Network of the International Center for Agriculture (CIAT). The variety is derived from the double cross CT-11519/CT-11492 that belongs to *Oryza sativa* indica subspecies carried out at CIAT (See technological file in the annexes).

Nicaragua was prone to drought and high temperatures in the area under study and, like the Central American area, to face the consequences of the “Niño and La Niña” phenomenon, therefore, in the current environmental situation, the growth of the liberalization of market and macroeconomic risks in the region, variation in productivity growth is an important mechanism for promoting economic prosperity in general and in the agricultural sector in particular (Pinstrup-Anderse 2002, Ruttan 2002, Zuniga 2020). The analysis of productive growth resources over time, and the productive differences between countries and regions, has been an important and relevant topic of formal analysis in the theory of economic growth and development for many years. A few decades ago, Hayami and Ruttan (1970) argued that the effect of productive growth in the agricultural sector is important if agricultural output is high enough to meet the growth in demand for food, vegetative material, and plants from the community. industrialization and urbanization. Furthermore, rapid rates of income and population growth are expected to double the demand for agricultural products over the next 50 years. Hence, the substantial utility in productivity will be added to keep in balance with the increase in demand (Ruttan 2002, Zuniga 2020).

Capalbo et al. (1990) explain that the study of productivity can be carried out at different levels, for example, companies, sectors, regions, or countries. Several studies have estimated productivity growth across countries using aggregate data (Capalbo et al. 1990, Fulginiti and Perrín 1998, Coelli and Rao 2005). Country-level studies are useful in formulating policies at the micro level.

For this reason, the work has been organized in a second section that explains the DEA methodology and the applied Malmquist index, in the third section, it is presented how the data for the study and its characteristics were organized, and in the fourth section, the results are presented, and discussion of the study findings and finally the research conclusions.

Methodology

In the present study, total factor productivity (TFP) is measured using the Malmquist index method described in Färe et al. (1994) and Coelli et al. (1998, Chapter 10). This approach uses the data envelope analysis (DEA) method to construct a linear segment of production for each year in the sample. Hence, a brief description of the DEA method is provided prior to the description of the Malmquist TFP calculations. As has been established in the literature, productivity growth can be broken down into technical efficiency change (CET) and technological change (CT), in turn, CET is broken down into pure efficiency change (ETP) and change in efficiency at scale (CETE) (Coelli et al. 2005).

This decomposition is important because the change in technical efficiency (CET) can be interpreted as a measure related to skill management (agronomic management, technical assistance and training) given the technology in our case it would be the INTA Chinandega rice variety, while technological change (TC) indicates the growth in productivity that arises from the adoption of new production practices. The change in total technical efficiency of production (CETP) and the change in technical efficiency (CETE) are related to changes in costs associated with growth and farm size**.**

Consequently, the utility in the change of the technical efficiency (CET) is derived from the improvement of the skill in agronomic management, these yields are related to a model of variables including experience and education. In contrast, the driving force behind the technological change (TC) was an investment in research and technology where CETE and CETP are determined by the ability of the farm to invest and procure new resources in order to expand its size (Zuniga 2020, Leudena 2010, Bravo-Urethra 1994).

Development Data Analysis (DEA)

Evolutive data analysis or DEA for its acronym in English, is a linear programming methodology, it uses data of the input and output quantities of a group of producing farms[1] that use the technology that we evaluate to construct the linear segment of the surface of the set of data points. This Boundary surface is constructed by solving problems with a linear programming sequence (one for each farm in the studied sample). The degrees of technical inefficiency of each farm (distance between the observed data and the frontier) is produced as a product of the frontier built by the method (Leudena 2020, Zuniga 2020).

DEA analysis can be input-oriented or output-oriented. In the first case of oriented input, the DEA method defines the frontier to find the maximum proportional reduction possible with the use of output production, keeping input levels adjusted. The two measures provide the same technical efficiency score when constant returns to scale (CRS) are applied, but it is different when increasing or variable returns to scale (VRS) are assumed. In our study, the INTA Chinandega rice variety is considered to have variable returns to scale (VRS). In the study, an output-oriented has been selected because regularly in agriculture one usually assumes to maximize the output rather than the yield per manzana given a set of inputs.

Considering the data for N farms in the region (North Pacific of Nicaragua) in a particular period, the linear programming problem that is solved for the ith farm with a DEA model and output-oriented DEA is the following:

[1] The authors use this methodology for groups of countries or regions to construct the linear segment of the surface of the data set points.

$$max_{\phi,\lambda}\phi,$$

$$st \quad -\theta\gamma_i + \Upsilon\lambda \geq 0,$$

$$x_i - \mathrm{X}\lambda \ \geq 0,$$

$$\lambda \geq 0, \qquad (1)$$

Donde,

γ_i *is a* M x 1 Quantities vector for *i*th farm;

x_i is a K x 1 Quantities vector input for *i*th farm;

Y is a N x M Quantities matrix output for all N farms;

X is a N x K Quantities matrix for all N farms;

λ is an N x 1 weight vector; and

ϕ *i*s a scalar.

It is observed that ϕ will take the value greater than or equal to 1, and that φ – 1 is the increase proportional to the outputs that can be carried out by each ith region, keeping the input quantities constant. It can also be noted that 1/ φ defines the estimate of the technical efficiency (TE) that varies between 0 and 1 (this is the out-oriented score that I report in the results).

The linear programming (LP) above is to solve for N periods once for each farm in the sample. Each PL produces a vector θ and λ. The parameter θ provides information on the technical efficiency score for the ith farm. The pair of the ith farm are the efficient farms that define the segment of the frontier against which the ith (inefficient) farm is projected.El problema DEA puede ser ilustrado usando un simple ejemplo. Consideremos el caso donde hay un grupo de five farms producing two outputs (eg, bean (Been) and rice (Rice)). It is assumed for simplicity that each farm has identical input vectors. These five farms are described in Figure 1. Farms A, B and C are efficient farms because they have defined the frontier. Farms D and E are inefficient farms. For each farm D the technical efficiency score is equal to

$$TE_D = \frac{OD}{OD'} \qquad (2)$$

We assume even farms for A and B. In the DEA output the farm is listed that would have a technical efficiency score of approximately 70% and would have non-zero λ-weights associated with farms A and B. For farm E the score of the technical efficiency is equal to

$$TE_E = \frac{OE}{OE'} \qquad (3)$$

We assume even farms for B and C. The DEA output lists the farm that would have a technical efficiency score of approximately 50% and would have a non-zero λ-weight associated with farms B and C. Note that the DEA output lists for farms A, B, and would provide the technical efficiency score equal to one and each farm would be on its own pair. For further discussion of the DEA method see Coelli et al. (1998, Chapter 6).

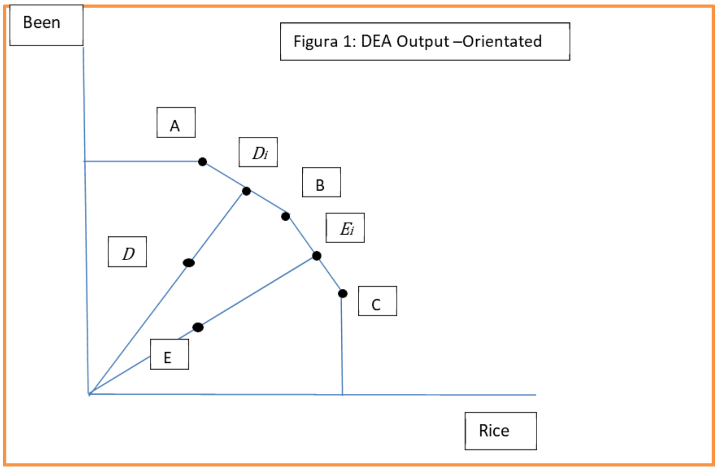

Fig. 1 DEA Output-Oriented

Malmquist PTF Index

Malmquist PTF is an index defined using a distance function. A distance function describes a multi-input, multi-output production technology[2] without the need to specify the target behavior (such as cost minimization or profit maximization). Both distance functions can be defined. An input distance function characterizes the production technology by seeking a minimum proportional contraction for the input vector, given an output vector. An output distance function considers the maximum proportional expansion of the output vector, given an input vector. Only one output distance function is considered in detail in this scientific article. However, the inputs distance function can be defined using a similar way. A production technology can be defined using the output set, P(x), which represents the set of all vectors, y, which can be produced using the input vector, x. What is,

$$P(X) = \{y: x\ can\ produce\ y\} \tag{4}$$

The technology is assumed to assume the axioms listed in Coelli et al. (1998, Chapter 3). The distance function Output is defined on the output dataset, P(x), as:

$$d_0(x,y) = min\left\{0: \frac{y}{\delta} EP(x)\right\} \tag{5}$$

The distance function, d_0 (x, y), will take a value less than or equal to 1 if the output vector, y ,

[2] INTA-Chinandega rice variety promoted by INTA North Pacific.

is an element of the feasible production set, P(x). Furthermore, the distance function will take a value equal to unity if y is located at the outer boundary of the feasible production set, and it will take a value greater than one if y is located within the feasible production set. DEA as a method are used to calculate the distance measurement in this study. These are briefly discussed. The Malmquist TFP index measures the change between two data points (e.g. given a particular farm in two adjacent periods) by calculating the ratio of the distance of each data point relative to a common technology. Following Färe et al. (1994), The change of the Malmquist TFP index (output-oriented) between period s (the base period) and period t is given by

$$m_0(y_s, x_s, y_{t,}) = \left[\frac{d_0^s(y_t, x_t)}{d_0^s(y_s, x_s)X} * \frac{d_0^t(y_t, x_t)}{d_0^t(y_s, x_s)}\right]^{1/2}, \qquad (6)$$

Where the notation d_0^s (y_t,x_t) represents the distance of the period t observation from the technology of period s. A value of m_0 greater than 1 will indicate a positive growth of the TFP index from period s to period t, while a value less than one will indicate a deterioration in the TFP. Note that equation (6) is actually the geometric average of two TFP indices. The first is evaluated with respect to the technology of period s and the second with respect to the technology of period t.

An equivalent way of writing this productivity index is

$$m_0(y_s, x_s, y_{t,} y_t) = \left[\frac{d_0^s(y_t, x_t)}{d_0^s(y_t, x_t)} * \frac{d_0^t(y_s, x_s)}{d_0^t(y_s, x_s)}\right]^{1/2}, \qquad (7)$$

where the ratio outside the square brackets measures the change in the output-oriented measure of Farrel's technical efficiency between periods s and t. That is, the change in efficiency equivalent to the ratio of the technical efficiency in period t to the technical efficiency in period s. The remaining part of the index in equation (2) is a measure of technical change. It is the geometric average of the change in technology between the two periods, evaluated in x_t and also in x_s.

Following Färe et al. (1994), and given the appropriate panel of data available, the Malmquist PTF index distance measure needs to be computed using DEA as linear programming programs. For the *ith* farm, four distance functions are calculated in order to measure the change in TFP between the periods, s and t. This requires solving four linear programming problems. Färe et al. (1994) assume constant returns to scale (CRS) in their analyses. The PLs are:

$$\begin{aligned}
&d_0^t(y_t, x_t)^{-1} = max_{\phi}, \lambda, \phi \\
&st\ -\ \phi y_{it} + Y_t\lambda \geq 0, \\
&X_{it} -\ X_t\lambda \geq 0, \\
&\lambda \geq 0,
\end{aligned} \qquad (PLs\ 8)$$

$$\begin{aligned}
&d_0^t(y_s, x_s)^{-1} = max_{\phi}, \lambda, \phi \\
&st\ -\ \phi y_{is} + Y_t\lambda \geq 0, \\
&X_{is} -\ X_t\lambda \geq 0, \\
&\lambda \geq 0,
\end{aligned} \qquad (PLs\ 9)$$

$$d_0^s(y_t, x_t)^{-1} = max_{\phi}, \lambda, \phi$$
$$st \; - \; \phi y_{it} + Y_s\lambda \geq 0,$$
$$X_{it} - \; X_s\lambda \geq 0,$$
$$\lambda \geq 0, \qquad (PLs\ 10)$$

Note that in PLs (9) and (10), the production points are compared to technologies of different time periods to 1, as it should be when calculating the technical efficiency of the output oriented standard. The data point could be located above the production frontier. This would commonly occur in the PL (10) here the production point of period t is compared to the closest technology in the period. (s). If technical progress has occurred, then a value of $\varphi < 1$ is possible. Note that it could also possibly occur at PL(10) if the technical regression has occurred, but this is less likely.

The returns to scale of the technology is an issue to consider, as they are very important in measuring TFP. An REV technology is used in this study for two reasons. First, since the analysis involves the use of aggregated farm-level data, it does not appear to be sensitive to considering REC technology. The use of technology at variable returns to scale when the sum of the data is expressed as the average of a farm could be discussed, but distributed with aggregate data (as is the case in this study), the use of technology at REC is only one sensible option.

In addition, in the comment above regarding the use of aggregate data, a second argument for the use of a REC technology is applicable to farms with levels of aggregate data. Grifell-Tatjé and Lovell (1995) use a simple one-input, one-output example to illustrate that the Malmquist TFP index may not correctly measure TFP change when REV is assumed for technology. Hence, it is important that technology to REC can be done using Malmquist index PTF DEA. Otherwise, the results may not appropriately measure the gains or losses resulting from scale effects.

2 Data

The present study was based on the description of data provided in the Institutional Development Office of the North Pacific INTA delegation. The following are some characteristics of the data series used.

2.1 Farm Coverage

The study included 40 farms that have constantly developed INTA Chinandega technology and represent 34% of the producers in the western zone that have been experimenting with rice production technologies. The producers that participated are from the municipalities of Chichigalpa, El Viejo, and Chinandega (see table 1, annexes).

2.2 Period of time

The study period includes the productive cycles from 2003 to 2009. In these 7 productive cycles, the data was organized in data panels in such a way that we selected 40 producers who have been sowing the variety of seed proposed by INTA to implement the transfer of technology, this allows organizing the data in panels.

2.3 Output Serial

The output series represents the income (the amounts of rice measured in quintals by its price), obtained by each farm during each study period.

2.4 Serial Input

Given the restrictions in the number of input variables that must be considered in the DEA analysis, and the limitations in the management of the database available by the Office of Institutional Development of INTA Pacífico Norte, this study considers only two inputs.

Area: this variable refers to the planted area of each farm, during the study period.

Costs: this variable refers to the total costs per block generated in each study period for each farm studied. Total costs are expressed in local currency of the study period. The total costs are for the management of the rice crop and consider the cost for the use of labor for cleaning, sowing, fumigation, fertilization, harvesting, rental of agricultural implements, as well as inputs used to control the chupador, for the broad leaf, for blast, for the spot, for grasses, technical assistance, training, seeds, and materials.

Results

Given that there are 7 production cycles studied in the western region of Nicaragua, there is a set of linear programming calculations to describe. The calculations[3] involve the solution of 40 *(6 X 3 - 2) = 760 LP problems.

Table 2[4] of the annexes shows the average technical efficiency at constant and variable returns to scale for all the farms studied during the 2003, 2006 and 2009 production cycles. Note that on average the record of technical efficiency at returns of constant scale (REC) was 0.55 and at returns of variable scale (REV) 0.66 in the year 2003, it implies that these producers, on average, were producing inefficiently at -45.4% keeping the planting area and yield per manzana[5] constant and -34 % under conditions of variation in the planting area and the yield per block. This situation improves in 2006 with -40.8% and -30.3% respectively, remaining close to the previous period for 2009.

Likewise, it can be noted that the product of the REC between the REV indicates growth or decrease in returns to scale, in this sense farm 35 in 2006 experienced growth to returns to scale, however the farm in question always maintained an area of two manazas implying, on the other hand, we observed a group of farms that remained indifferent to varying the size of the planting area and the remaining group show decreases in the frontier level producing below 100% of their technical efficiency .

The pairs using the enveloping data analysis during the 2003, 2006 and 2009 production cycles are presented in table 3 of the annexes. In this table 3 it is possible to identify the farms that define the technological frontier with the INTA Chinandega rice variety for the years 2003, 2006 and 2009. The last columns show the number of times that the efficient farms in the technological frontier appear as pair of technically inefficient farms. It can be noted that farm 03 is located on the border to serve as a reference for 19 farms, farm 25 serves as a reference for 28 farms, farm 22 serves as a pair for 28 farms, farm 29 serves as a pair for 8 farms, and farm 38 serves 7 times during the year 2003. In 2006 farm 03

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[3] The calculations are Nx(3T-2) PL, where N is the number of cases or farms studied (40), T is the period, equal to 6.

[4] Note in the tables of the results, values greater than 1 indicate improvement, and less than 1 deterioration. To get growth rates (%), subtract 1 from the values and multiply by 100.

[5] 1 manzana is equal to 0.698896 ha.

continues as for this, although reducing to 10 farms, farm 05 appears as a reference to 20 farms, farm 22 serves as a pair to 3 farms, farm 25 was a pair of 21 farms, farm 28 was a pair of 16 farms, farm 29 was a pair of 3 farms. During the year 2009 farm 29 remained as a pair in the three periods, appearing as new pair farms 15, 26, and 28.La tabla 4 de los anexos muestra el promedio de los cambios en la eficiencia técnica, la tecnología de la variedad de semilla de arroz INTA Chinandega, la eficiencia pura, la eficiencia a escala y la productividad total de los factores, durante los ciclos productivos 2003 hasta el 2009. Las fincas son mostradas en la tabla en orden descendente de las mayores a menores magnitudes de los cambios del índice de la PTF. La finca 24 presentó el índice más alto con un ritmo de crecimiento en la PTF de un 13 %, explicado por un 13 % en el crecimiento promedio de la eficiencia técnica, complementado por un decrecimiento de -0.5 % en la capacidad tecnológica. Las estimaciones de la eficiencia técnica se descompone en el cambio de la eficiencia pura referida al manejo de la variedad INTA Chinandega con un buen ritmo de crecimiento del 13 %, sin embargo el tamaño del área sembrada registró el 0.07 % de la capacidad o eficiencia de escala. Esta misma consideración se analiza para las fincas 26, 31, 15, 9, 12, 14, 23, 37, 35, 39, 27, 36, 1, 28, 8, 32, y 34. Las fincas 6, 7, 18, 19, 20 21, y 30 se mantuvieron en la frontera explicado por el 1 % del cambio tecnológico y complementada por un decrecimiento de -0.5 % del cambio de su eficiencia técnica, a su vez la eficiencia técnica fue explicada por las mantener constantes el tamaño del área sembrada, a excepción de la finca 30 que mantuvo contante el tamaño de la finca, pero con mayor ritmo de crecimiento en la eficiencia técnica pura. En promedio el conjunto de las 40 fincas se mantuvoen la frontera tecnológica con un valor de 1 como índice de PTF, explicado en un 0.08 % en su eficiencia técnica, y de igual puntaje casi mejorado para la tecnología aplicada (INTA Chinandega) con un 99 % de su capacidad, el puntaje de la eficiencia técnica es explicado por el -0.5 % de la capacidad en la eficiencia pura, es decir por el manejo de la asistencia técnica, y no por el tamaño del área sembrada que tuvo un ritmo de crecimiento del 1 % en su capacidad a escala.

Table 5 shows the annual average change in technical efficiency, technological change, pure efficiency change, scale efficiency change, and total factor productivity change.

There is an improvement in the TFP starting in 2006 with a 5% average annual growth rate in the TFP, which was maintained until 2008, declining in 2009. In 2006 the TFP index is explained by 4% in the average annual growth rate of labor efficiency, and complemented by technological change that reached 0.09%. The technical efficiency is explained fundamentally by a 7% of the pure efficiency that implies the technical assistance and the INTA training in technology transfer with the INTA Chinandega rice seed variety, complemented by a -3%% of the capacity of the INTA. optimal area size. In 2007, the TFP index is explained by an improvement in technical efficiency that reached 17%, complemented by a decrease of -9.1% in technological capacity. The technical efficiency estimates are explained by 13% of its pure technical efficiency, and 3% of its scale efficiency. to capacity. Finally, in 2008 it maintained the interannual growth rate of the productivity of the farms studied with 1% TFP. This index is explained by a deterioration of -19.5% in the capacity of its technical efficiency, complemented by 32% of technological change, which means that this year there was a notable impact on the management of the INTA Chinandega variety. The technical efficiency was marked by -7.8% of the interannual growth rate of the planted area, reaching returns to scale in the economy of the farms studied, that is, this year technical assistance and training or agronomic management were not decisive to reach the technical efficiency that recorded a deterioration of -12.7% of its capacity.

Table 5 Annual average change in technical efficiency, technological change, pure efficiency change, scale efficiency change, and total factor productivity change.

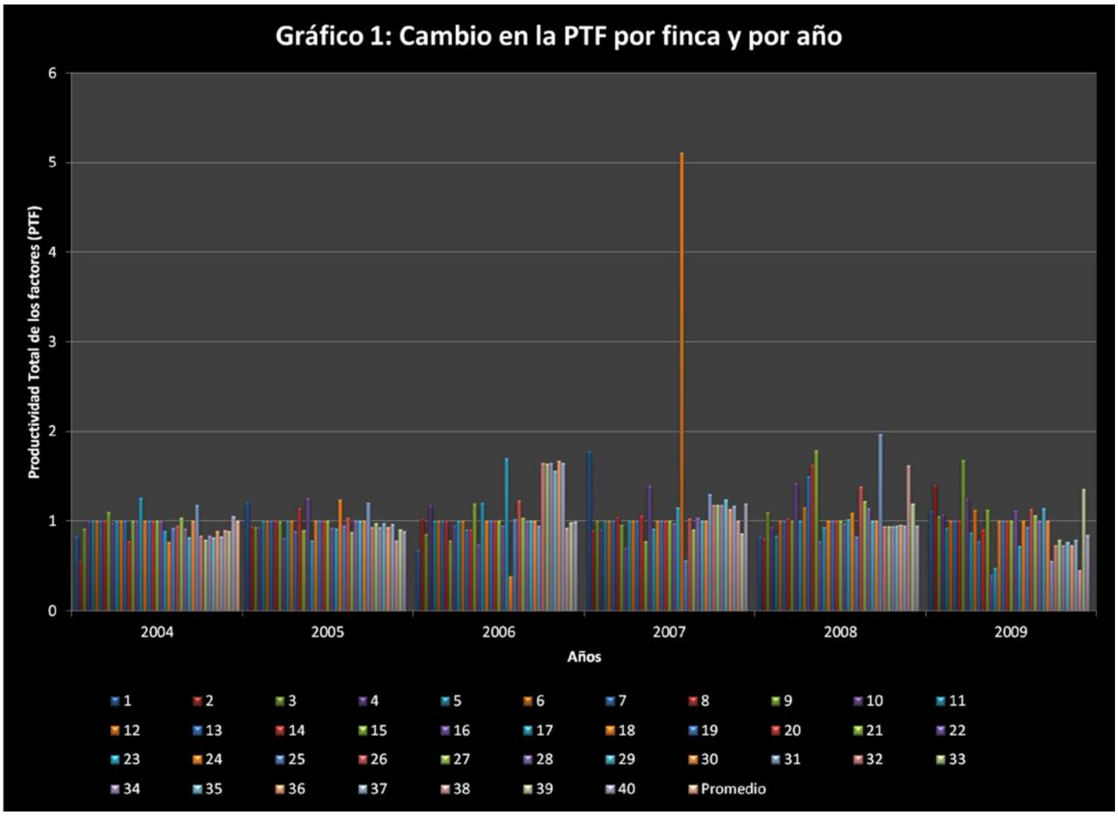
Years	Efficiency change variation	Technological change variation	Pure Eficiency change variation	Scale efficiency Change variation	PTF variation
2004	1.04	0.901	1.012	1.027	0.937
2005	0.999	0.978	0.972	1.027	0.976
2006	1.039	1.009	1.071	0.97	1.048
2007	1.171	0.909	1.132	1.034	1.065
2008	0.805	1.329	0.873	0.922	1.07
2009	1.029	0.891	0.94	1.095	0.917

Note: All Malmquist index average are geometric average.

Graph 1 shows the change in total factor productivity per farm during the study period. Farm 24 draws our attention, which in 2007 registered an index of 5.15 PTF and that as of that year I doubled the planting area. In that same year farm 1 maintains a growth rate beyond the technological frontier and although it does not double its planting area, it increases in size in 2004, 2007 and 2009. In each year the farms that present a TFP index greater than 1 determine the technological frontier, and farms with a TFP index of less than 1 imply deterioration in their economies for not achieving the competitiveness of the technological frontier (INTA CHINANDEGA).

Table 6 shows the maximum and minimum changes in the growth rate of total factor productivity and its breakdown into technical efficiency and technological change, by the municipality during the 2003-2009 period.

The municipality where the INTA Chinandega technology impacted positively and in a representative manner, with respect to its maximums and minimums, was in the municipality of El Viejo with a 13% growth rate of the TFP, and in the same way it is identified that this Productivity was mainly due to the technical efficiency of the workers and technicians rather than the variety of rice as such.



Graph 1 TPF changes by farm and years.

Table 6 Maximum and minimum changes in the growth rate of total factor productivity and its breakdown into technical efficiency and technological change, by the municipality during the 2003-2009 period.

Municipality	PTF change		Efficiency change		Technological change	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
El Viejo	1.128	0.857	1.134	0.877	0.995	0.977
Chichigalpa	1.12	0.886	1.134	0.893	0.097	0.992
Chinandega	1.091	0.861	1.106	0.971	0.986	0.988

Note: Values greater than 1 indicate improvement, and lower deterioration. To get growth rate (%), subtract 1 from the values and multiply by 100.

Secondly, we observe that Chichigalpa presented an interannual growth rate in the productive cycles of 12% in the TFP and that its causes are similar to those of El Viejo, that is, due to the technical efficiency of the workers in the management of the variety rather than the variety itself.

Finally, Chinandega presents the lowest growth rate with 9% year-on-year per production cycle. Similarly, this growth rate was due to the technical management of the producers.

3 Conclusions y discussion

The results focused on measuring the productivity growth rate of the farms studied in order to strengthen the food security policy to ensure the production, distribution and consumption of the INTA CHINANDEGA rice variety.

The farms studied maintained a growth rate of 1% in the TFP from the year 2006, maintaining it until 2008. It can be assumed that the first years of the study 2003-2005 were of adaptability for the set of farms, however we found farms that individually the growth rate was higher. 48% of the farms studied remained in an average range of productivity between 13 and 1 percent, this productivity is explained by the assimilation of producers in terms of technological education. 20% of the farms studied remained on the technological frontier, this was explained by changes in technology and technical efficiency at scale, that is, they were favored by the planted area and the benefits of the INTA CHINANDEGA seed than by the assimilation of technical assistance and education and 32% were close to the technological frontier, reaching between 99 and 86 percent of the capacity of the technology (INTA CHINANDEGA), was explained by the non-assimilation of technical assistance, nor the use of the suitable area. With these results, we can assure that these farms under study have adopted the technology and have contributed to reducing the gap between imports and national production with an average annual production of 31,790 quintals of rice and a total production in the 7 years of 222,534. quintals.

However, it is important to make the observation in terms of input to the makers of sectoral policy about considering 1% of the growth rate of technical efficiency at scale (optimal size of the area to be planted), combined with 0.08% of technical efficiency , which means technical assistance and education in this direction to improve the rate of growth of productivity per farm.

The discussion is based on table 7 because in Nicaragua, it is the first study that applies this methodology, however we can observe that the studies of colleagues in the table cited have taken the country as a reference and it is the closest we can relate the results of this regional study with the country study.

Table 7 Results of previous studies that applied the Malmquist TFP index

Autores	Coelli and Prasada	Leudena Carlos	Nin et al.	Avila and Evenson	Trueblood and Coggins	Arnade
Fecha estudio	-2005	2010	2003	2004	2003	1998
# Países	93	120	115	82	115	70
Periodo	1980-2000	1961-2007	1965-94	1961-2001	1961-91	1961-93
Método	DEA	DEA	DEA	OLS		DEA
Nicaragua	1.018	1.014		1.016	0.964	0.998

Fuente: Leudena (2003)

In this sense, the results of the study in geometric average are similar to the results of previous studies applied to Nicaragua. Colleagues in the different study periods report a TFP of 1.8% on an inter-annual average, in our study the average is 1.4%.

Finally, the discussion is to assess whether the TFP growth rate is greater than the population growth rate. In this sense, the results indicate that the interannual growth rate of the TFP was 1% on average, however we found farms in El Viejo that reached a maximum of 13% above the 1.3% growth rate of the Nicaraguan population. . Therefore, the impact of INTA CHINANDEGA technology is positive on food security in the western region. The results validate that the INTA CHINANDEGA variety contributes to the productivity of the economic units that adopted the technology and to the vital role of the primary sector in guaranteeing food security.
It is recommended to identify the farms that reached the growth rate of 13%, which represent 48% of the farms studied, since they would be the benchmark for adopting the technology.

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Anexos

Tabla 1: Productores incluidos en el Estudio por municipios			
Código	Finca No	Nombres y apellidos	Municipio
3	1	Ricardo Ruiz Martínez	Chinandega
5	2	Simón Noel Guerra	Chinandega
14	3	Juan Pablo Guido	Chinandega
22	4	José Tomas Ferrufino Martínez	Chinandega
27	5	Isaías Ordoñez Altamires	Chinandega
28	6	María Cristina Meza	Chinandega
29	7	Ramón Guadalupe Castellón Aguilar	Chinandega
30	8	César Domingo Castillo García	Chinandega
31	9	Esteban Jacinto Ordoñez	Chinandega
33	10	Lidia Catín Rivera	Chinandega
34	11	Luis Antonio Ordoñez Altamires	Chinandega
35	12	Esteban Flores Cáceres	Chinandega
36	13	José Francisco Chavarría	Chinandega
38	14	José Gregorio Landero Solís	Chinandega
41	15	José Tomás Ordoñez Quiroz	Chinandega
50	16	Thelma del Socorro Hernández	Chinandega
53	17	Luis Alvarado	Chinandega
57	18	Wilfredo Antonio Yuritza Chávez	Chichigalpa
58	19	Miguel Ángel Paredes Munguía	Chichigalpa
59	20	Faustino Héctor Sarria Mayorga	Chichigalpa
60	21	Justo Germán Ruiz	Chichigalpa
62	22	Antonio Ruiz	Chichigalpa
71	23	Carlos Palma	El Viejo
82	24	Félix Ramón Sarria Poveda	El Viejo
83	25	Luis Felipe Carrillo Aguilar	El Viejo
86	26	Gerald Ruiz	Chichigalpa
88	27	Wilfredo Vanegas	Chichigalpa
91	28	Juan Sarria	Chichigalpa
92	29	Elías Castillo	Chichigalpa
94	30	Cliford Elías Castillo Rivas	Chichigalpa
96	31	Marcelino Malta	El Viejo
97	32	Reynaldo Meza Picado	El Viejo
98	33	Geraldo Carrillo	El Viejo
101	34	Luis Felipe Carrillo	El Viejo
102	35	Miguel Ángel Paz	El Viejo
107	36	Ariel Alberto Medina Henrique	El Viejo
110	37	Julio Treminio	El Viejo
112	38	Aura Vega González	Chichigalpa
114	39	Félix Justo Romero Córdoba	Chichigalpa
115	40	José Isidro García Ruiz	Chinandega

Fuente: Oficina de Desarrollo Institucional, ODI. INTA Pacífico Norte.

Tabla 2: Eficiencia Técnica a REC y REV en los ciclos 2003, 2006 y 2009

Ciclo productivo 2003					Ciclo productivo 2006					Ciclo productivo 2009				
Finca	ETREC	ETREV	ESCALA		Finca	ETREC	ETREV	ESCALA		Finca	ETREC	ETREV	ESCALA	
1	0.605	0.655	0.923	drs	1	0.492	0.554	0.887	drs	1	0.688	0.762	0.903	drs
2	0.519	0.562	0.923	drs	2	0.339	0.363	0.936	drs	2	0.301	0.324	0.928	drs
3	0.797	1	0.797	drs	3	0.714	1	0.714	drs	3	0.774	0.978	0.792	drs
4	0.588	0.605	0.972	drs	4	0.787	0.917	0.858	drs	4	0.609	0.74	0.823	drs
5	0.661	0.892	0.741	drs	5	0.804	1	0.804	drs	5	0.518	0.692	0.748	drs
6	0.732	0.942	0.777	drs	6	0.743	0.895	0.831	drs	6	0.714	0.795	0.898	drs
7	0.495	0.557	0.888	drs	7	0.503	0.514	0.978	drs	7	0.482	0.503	0.959	drs
8	0.574	0.574	1	-	8	0.682	0.715	0.953	drs	8	0.665	0.754	0.882	drs
9	0.474	0.479	0.991	drs	9	0.509	0.555	0.918	drs	9	0.756	0.831	0.91	drs
10	0.547	0.569	0.961	drs	10	0.519	0.529	0.981	drs	10	0.6	0.613	0.978	drs
11	0.392	0.443	0.884	drs	11	0.475	0.536	0.887	drs	11	0.355	0.413	0.86	drs
12	0.492	0.672	0.732	drs	12	0.571	0.729	0.784	drs	12	0.666	0.77	0.864	drs
13	0.492	0.634	0.777	drs	13	0.39	0.51	0.765	drs	13	0.455	0.512	0.889	drs
14	0.516	0.587	0.879	drs	14	0.51	0.57	0.894	drs	14	0.72	0.842	0.855	drs
15	0.492	0.672	0.732	drs	15	0.554	0.783	0.707	drs	15	0.903	1	0.903	drs
16	0.714	0.833	0.857	drs	16	0.833	0.947	0.88	drs	16	0.312	0.352	0.887	drs
17	0.519	0.562	0.923	drs	17	0.745	0.821	0.907	drs	17	0.264	0.288	0.918	drs
18	0.569	0.976	0.583	drs	18	0.661	0.995	0.664	drs	18	0.555	0.762	0.729	drs
19	0.538	0.719	0.749	drs	19	0.625	0.762	0.82	drs	19	0.525	0.671	0.782	drs
20	0.492	0.793	0.62	drs	20	0.48	0.769	0.624	drs	20	0.48	0.557	0.861	drs
21	0.646	0.863	0.749	drs	21	0.606	0.82	0.739	drs	21	0.63	0.703	0.896	drs
22	0.586	1	0.586	drs	22	0.625	1	0.625	drs	22	0.615	0.729	0.843	drs
23	0.349	0.392	0.888	drs	23	0.471	0.471	1	-	23	0.416	0.432	0.964	drs
24	0.353	0.397	0.888	drs	24	0.127	0.167	0.761	drs	24	0.75	0.811	0.925	drs
25	1	1	1	-	25	1	1	1	-	25	0.456	0.485	0.94	drs
26	0.391	0.889	0.44	drs	26	0.583	1	0.583	drs	26	0.832	1	0.832	drs
27	0.367	0.535	0.687	drs	27	0.422	0.616	0.684	drs	27	0.42	0.531	0.792	drs
28	0.893	0.901	0.991	drs	28	1	1	1	-	28	1	1	1	-
29	1	1	1	-	29	1	1	1	-	29	1	1	1	-
30	0.604	0.686	0.879	drs	30	0.734	0.827	0.888	drs	30	0.63	0.734	0.858	drs
31	0.313	0.315	0.991	drs	31	0.522	0.56	0.932	drs	31	0.76	0.813	0.935	drs
32	0.366	0.44	0.833	drs	32	0.458	0.511	0.896	drs	32	0.39	0.405	0.964	drs
33	0.359	0.404	0.888	drs	33	0.458	0.458	1	-	33	0.424	0.448	0.946	drs
34	0.366	0.412	0.888	drs	34	0.458	0.458	1	-	34	0.39	0.412	0.946	drs
35	0.349	0.349	1	-	35	0.438	0.465	0.94	irs	35	0.416	0.416	1	-
36	0.338	0.381	0.888	drs	36	0.464	0.464	1	-	36	0.39	0.412	0.946	drs
37	0.346	0.346	1	-	37	0.476	0.476	1	-	37	0.442	0.458	0.964	drs
38	0.76	1	0.76	drs	38	0.6	0.65	0.922	drs	38	0.385	0.426	0.903	drs
39	0.608	0.644	0.944	drs	39	0.586	0.661	0.888	drs	39	0.671	0.734	0.914	drs
40	0.627	0.733	0.855	drs	40	0.714	0.805	0.888	drs	40	0.598	0.699	0.855	drs
Prom	0.546	0.66	0.847		Prom	0.592	0.697	0.863		Prom	0.574	0.645	0.895	

ETREC=eficiencia técnica de REC DEA

ETREV=eficiencia técnica de REV DEA

ESCALA= eficiencia de escala=ETREC/ETREV

REC=rendimientos de escala constante

REV=rendimientos de escala variable

DEA= Análisis de datos envolventes

DRS= Decrecimiento a escala

IRS=Crecimiento a escala

Tabla 3: Pares de DEA 2003, 2006 y 2009

	Pares cada ciclos productivo:									Conteo*		
Finca	2003			2006			2009			2003	2006	2009
1	25	29		5	28		26	15	28	0	0	0
2	25	29		5	28		28	26	15	0	0	0
3	3			3			26	28		19	10	0
4	25	38		5	28		26	28		0	0	0
5	3	22		5			28	26		0	20	0
6	25	3		25	5	3	28	26	15	0	0	0
7	3	25		5	28	25	28	26	15	0	0	0
8	25			5	25	28	26	15	28	0	0	0
9	29	25		5	25	28	26	15	28	0	0	0
10	25	38		5	25	28	15	28		0	0	0
11	38	25		28	5		28	26		0	0	0
12	3			5	3	25	26	15	28	0	0	0
13	25	3		3	25	5	26	15	28	0	0	0
14	3	38	25	5	25	28	26	28		0	0	0
15	3			3	25		15			0	0	21
16	25	29		28	29		29	28		0	0	0
17	25	29		28	29		29	28		0	0	0
18	3	22		3	5	22	28	26		0	0	0
19	3	25		3	5	25	28	26		0	0	0
20	3	22		22	3		28	26	15	0	0	0
21	3	25		25	3		28	26	15	0	0	0
22	22			22			15	26		5	3	0
23	3	25		25			15	28		0	0	0
24	3	25		25	3		28	26	15	0	0	0
25	25			25			15	28		28	21	0
26	22			26			26			0	0	24
27	3	38	22	22	5		28	26		0	0	0
28	29	25		28			28			0	16	35
29	29			29			29			8	3	2
30	3	38	25	5	28		28	26		0	0	0
31	25	29		28	5	25	28	15		0	0	0
32	3	25		3	25		15	28		0	0	0
33	3	25		25			15	28		0	0	0
34	3	25		25			15	28		0	0	0
35	25			25	29		28			0	0	0
36	3	25		25			15	28		0	0	0
37	25			25			15	28		0	0	0
38	38			5	25	28	28	26		7	0	0
39	25	29		5	28		28	26		0	0	0
40	38	25		5	28		26	28		0	0	0

* El conteo es el conteo del par que significa el número de veces que

Tabla 4: Promedio de los cambios de la eficiencia técnica, tecnológico, eficiencia pura, eficiencia a escala, productividad total de los factores, durante los ciclos productivos 2003-2009

Finca	Cambio Eficiencia Técnica	Cambio Tecnológico	Cambio en la eficiencia pura	Cambio en la eficiencia a escala	Cambio en la productividad total de los factores
24	1.134	0.995	1.126	1.007	1.128
26	1.134	0.987	1.02	1.112	1.12
31	1.16	0.963	1.171	0.99	1.117
15	1.106	0.986	1.068	1.036	1.091
9	1.081	0.978	1.096	0.986	1.057
12	1.052	0.992	1.023	1.028	1.044
14	1.057	0.985	1.062	0.995	1.041
23	1.03	0.998	1.016	1.014	1.028
37	1.042	0.985	1.048	0.994	1.026
35	1.03	0.993	1.03	1	1.022
33	1.028	0.993	1.017	1.011	1.021
39	1.017	1.004	1.022	0.995	1.021
27	1.023	0.997	0.999	1.024	1.02
36	1.024	0.995	1.013	1.011	1.019
1	1.022	0.996	1.025	0.996	1.017
28	1.019	0.996	1.018	1.001	1.015
8	1.025	0.99	1.046	0.979	1.014
32	1.011	0.998	0.986	1.025	1.009
34	1.011	0.998	1	1.011	1.009
4	1.006	0.994	1.034	0.973	1
6	0.996	1.004	0.972	1.024	1
7	0.996	1.004	0.983	1.013	1
18	0.996	1.004	0.96	1.038	1
19	0.996	1.004	0.989	1.007	1
20	0.996	1.004	0.943	1.056	1
21	0.996	1.004	0.966	1.03	1
30	1.007	0.993	1.011	0.996	1
10	1.016	0.978	1.012	1.003	0.993
13	0.987	1.004	0.965	1.023	0.991
22	1.008	0.981	0.949	1.062	0.989
29	1	0.989	1	1	0.989
40	0.992	0.991	0.992	1	0.983
11	0.984	0.994	0.988	0.995	0.978
3	0.995	0.978	0.996	0.999	0.973
5	0.96	0.998	0.959	1.002	0.958
2	0.913	0.994	0.912	1.001	0.908
17	0.894	0.995	0.894	0.999	0.889
38	0.893	0.992	0.868	1.029	0.886
16	0.871	0.988	0.866	1.006	0.861
25	0.877	0.977	0.886	0.99	0.857
Prom	**1.008**	**0.992**	**0.996**	**1.011**	**1**

Nombre de la tecnología: INTA CHINANDEGA, VARIEDAD DE ARROZ (***Oryza sativa L.***) MEJORADA PRECOZ PARA CONDICIONES DE SECANO FAVORECIDO Y RIEGO		Código: GB-012
Nombre común: SEN -10	**Nombre científico:** *ORYZA SATIVA L.*	
Palabra clave 1: Arroz	**Palabra clave 2:** Precoz	Palabra clave 3: Secano y riego

I. Descripción de la tecnología:

1.1 Características Agronómicas de INTA CHINANDEGA

Vigor comercial	: Vigoroso
Días a flor	: 75
Altura de planta	: 90 cm
Excerción de espiga	: Buena
Densidad de espiga	: Intermedia
Color de la testa	: Paja
Longitud de espiga	: 24 cm
Habilidad de macollamiento	: Buena
Reacción al acame	: Resistente
Reacción a Pyricularia	: Resistente
Peso de 1000 granos (g)	: 27
Número de granos/espiga	: 135
Días a cosecha	: 105
Potencial genético	: 120 (Riego), 100 (Secano)
Recomendado para	: Riego y secano favorecido
Origen	: CIAT-Colombia.

1.2 Origen de la variedad

La variedad INTA CHINANDEGA proviene del VIOFLAR 1997 de la Red de Arroz de Centroamérica del Centro Internacional de Agricultura Tropical (CIAT). La variedad es derivada de la cruza doble CT-11519/ CT-11492 que pertenece a *Oryza sativa* subespecie *indica* realizada en CIAT.

1.3 Adaptabilidad

INTA CHINANDEGA se puede sembrar desde el nivel del mar hasta los 800 m, se adapta a suelos Arcillosos y Franco arcillosos. Con pH de 5.6 - 7.3, temperaturas de 22 a 31 ºC y precipitaciones de 1,200- 1,600 mm.

1.4 Zonas recomendadas

INTA CHINANDEGA se recomienda para las principales zonas arroceras de riego del país: Sébaco, Malacatoya, León, y en las zonas más favorecidas de arroz de secano: Chinandega, Jalapa, Pantasma, Río San Juan, Cárdenas - Rivas y RAAS.

1.5 Manejo agronómico

- **Época de siembra:** INTA CHINANDEGA es una variedad precoz de 105 días, recomendada para siembra de riego y secano favorecido. En riego de verano, en los meses de Diciembre y Enero. En secano, favorecido en la primera quincena de Julio.

- **Densidad poblacional:** La densidad de siembra de INTA CHINANDEGA, en riego al voleo 180 lb./mz y en condiciones de secano 160 lb./mz.

- **Fertilización:** La fertilización base se realiza al momento de la siembra para la modalidad de secano favorecido y a los 7 días de germinado para la modalidad de riego. La fertilización nitrogenada se recomienda en tres etapas diferentes de desarrollo del cultivar. La fertilización de la variedad INTA CHINANDEGA se recomienda así:

EPOCA	CANTIDAD QQ	FORMULA	ETAPA FENOLOGICA
Al momento de la siembra	2	Completo 12-30-10	Estado de plántula
A los 15 días de germinado	1.5	1ra Aplicación Urea 46%	Inicio del ahijamiento
A los 35 días de germinado	1.5	2da Aplicación Urea 46%	Máximo macollamiento
A los 50 días de germinado	1	3ra Aplicación Urea 46%	Inicio de primordio

- **Cosecha:** La variedad INTA CHINANDEGA debe cosecharse con humedad de grano de 20-22%, debido a que presenta maduración uniforme del grano; para evitar perdidas de la calidad industrial, no debe cosecharse con humedades menores al 20%.

Ventajas:

- Potencial de rendimiento de grano 100-120 qq/mz, supera en 44% al promedio nacional de rendimiento de grano.
- Características agronómicas deseables por los agricultores (buen vigor inicial, tolerancia a enfermedades especialmente a Pyricularia grisea y manchado de grano, buena senescencia y Excersión de panícula.
- Muchos productores de las zonas arroceras de secano, incrementan su producción y disminuyen sus costos de producción; además disminuyen los riesgos por ser una variedad precoz de 105 días.
- La calidad molinera de la variedad INTA CHINANDEGA, aumenta la rentabilidad, mejora la cristalinidad y el largo del grano.
- La uniformidad de maduración fisiológica es buena, lo que favorece la calidad de la semilla, disminuye las aplicaciones de insecticidas en el control de plagas de la panícula y el manejo de Post-cosecha.
- La rentabilidad de los productores de arroz en los sistemas de riego y secano favorecido es mayor con el uso de la variedad INTA CHINANDEGA.
- Alta fertilidad de la panícula.
- La calidad de grano trillado se superior a los estándares nacionales de arroz oro 80-20 de grano entero, ya que posee un 83 % de grano entero

Restricciones:

- La habilidad de macollamiento es buena, pero no sobrepasa los 22 tallos por planta.
- El desgrane de la panícula de INTA CHINANDEGA es intermedia.

1.5 Costo de la Tecnología:

COSTOS DE PRODUCCION /MZ	SISTEMA DE SIEMBRA
US$ 600.00	Riego
US$ 450.00	Secano

II. BENEFICIOS DE LA TECNOLOGIA

2.1 Beneficio económico

El costo de la tecnología por manzana de arroz de riego con la variedad INTA CHINANDEGA es de US$ 600.00, donde se obtienen rendimientos de 100-120 qq/mz. Es importante señalar que la variedad INTA CHINANDEGA, presenta alta resistencia a Pyricularia grisea y manchado de grano, disminuye los gastos en el control de enfermedades sobre todo de fungicidas, protegiendo así, la economía del productor y el medio ambiente.

INDICADORES	INTA CHINANDEGA	ALTAMIRA-9
Rendimiento (qq/mz)	120	80
Costo variable (US $)	600.00	612.00
Beneficio bruto de campo (US $)	1,500.00	1,000.00
Beneficio neto (US $)	900.00	388.00
Beneficio/costo (US $)	1.5	0.63

El costo de 1 qq de arroz granza comercial: US $ 12.50

El productor al sembrar INTA CHINANDEGA obtiene un beneficio neto por manzana de US 900.00, 43% más en relación a la variedad Altamira-9 (Variedad comercial), lo que representa que por cada Dólar invertido, se obtiene una ganancia de US $ 1.50.

2.2 Sociales

Aumento nacional de la producción de alimentos y reducción de las importaciones de tan importante grano, mejorando así los ingresos y bienestar de las familias productoras.

2.3 Ambiental

INTA CHINANDEGA presenta buena respuesta a las aplicaciones de nitrógeno, aunque su demanda no es mayor que el de la variedad comercial Altamira-9, a la que se recomiendan 4 qq/mz de Nitrógeno (Urea 46%). Además que su tolerancia a enfermedades especialmente a Pyricularia grisea es alta, así como al manchado de grano, lo que permite realizar una sola aplicación de fungicida en comparación con las otras variedades comerciales, a las que se les realizan hasta cuatro aplicaciones; representando esto una significativa reducción hasta del 80 % en químicos, permitiendo una menor afectación al medio ambiente.

III. Soporte técnico: Esta información es el estudio de 7 años de investigación por técnicos e investigadores del Proyecto de Investigación y Desarrollo del Programa de Arroz con la cooperación de la Misión Técnica Agropecuaria de la República de China-Taiwán. La información se encuentra en los Informes Anuales de Arroz 1997-2004 y el Programa de Arroz del INTA-CNIA.

INTA.Informe Técnico Anual de Arroz, 1997, 1998, 1999, 2000, 2001, 2002, 2003

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