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Evaluation on HYV of Pulse Crops in Myanmar

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Abstract

This paper shows the evaluation on HYV of pulse crops in Myanmmar. This system is evaluated based on growth decomposition model. The result of the area response function showed that the price of pulses was significant factor affecting farmers' land allocation decisions. The price of pulses and fertilizer, however, not affected output by influencing the utilization of inputs and hence, crop yield. The results of the area and yield response functions are consistent with the hypothesis of the study. The contribution of technology variables on changes in area, yield, and production will estimate by applying a decomposition model. The result showed that the adoption of HYVs and the increase in nitrogen use were the predominant sources of growth in pulses production.

Keyword: Myanmar agriculture, High yielding variety, supply response function, Myanmar pulses, decomposition model

1. Introduction

Myanmar pulses are important as a vegetable protein source in the daily diet of the Myanmar people. According to the statistics, per capita consumption of pulse is estimated to be 13kg. Due to the increase demand of pulses from India, Singapore, Malaysia, Indonesia, China and other countries, the country pulses production and export sharply increased during a short term period.

With the liberalization of economic system in 1988, the government accordingly adopted a system allowing farmers to cultivate crops by their choices and to process, transport and trade almost all the agricultural products.

The country's pulses export volume is the highest among the ASEAN countries. Greengram, Blackgram and Pigeonpea are the major export pulses, with lesser of Soybean and Cowpea. These pulses are also consumed domestically (green and blackgram sprouted, pigeonpea like dhal and soybean). There is much type of pulses that are locally important.

Myanmar Agricultural Produce Trading (MAPT) Department under the Ministry of Commerce has in recent years procured pulses from trades for their export. However, delivery quotas for farmers ranging from (2 to 3) 20-viss baskets per acre, purchased in the cool season 2000. Myanmar endeavors to increase area of the pulses and find the new buyers and markets. In 1997-98, the country's pulses export reached 769 thousand metric tons. Total export volume of blackgram, greengram and other pulses accounted for 307.6, 120.8 and 340.5 thousand metric tons respectively.

Since 1992-93, the Economic Development Year, integrated development strategy has been applied for agricultural development, with specific sector objectives and policies.

Main Objectives;
1) to achieve surplus in paddy production,
2) to achieve self-sufficiency in edible oil, [1]
3) to step up the production of exportable pulses and industrial crops.

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There were fluctuations in agricultural production, sown area, and yield per acre. The level of agricultural production was mainly dependent only on the weather. There were no significant improvements in the technology one situations, Institutional factors such as political instability, national unrest, pricing policy, and existing credit system hindered the agricultural program. These caused stagnation in the agricultural sector.

The improvement of technology and strengthening of institutions along with participation of the masses is implementing the government's economic plans. During the centrally planned economic era from 1962-63 to 1987-88, the highest sown area of pulses was 0.9 million hectares and total export volume was 24 to 142 thousand metric tons; during that period, country's pulses export was in the hands of government. In 1988, the government adopted market economic policies and introduced appropriate economic reform measures, while gradually reducing its direct involvement in the economy. In the era of agricultural marketing, the government has also become less involved end is encouraging the private sector to play a larger role.

The agricultural sector is the most important primary industry in Myanmar. Pulses are important as a vegetable protein source in the daily diet of Myanmar people. Presently, pulses are occupied nearly 43% of the crop area and dominates the agriculture sector, contributes 34% of value added in agriculture. Besides, it is a Myanmar export item for the generation income source of national economy.

The increase in pulses production in the 1970s was due to the expansion of the area under pulses cultivation rather than to increase in yields per hectare. During the 1970s, yield remained almost stagnant and increased only marginally in the 1980s. Growth in production is due to the expansion of pulses area and to the increase in yield per hectare. The rate of growth of agricultural production since independence has been slow pulses production regime the 1975 levels (million ton) only in 1980,81. After the introduction of new modern variety as the part of period-fixed, the supply of essential farm 3 inputs was increased and yields increased at the national level. Consequently, growth in pulses production increased due to the adoption of market oriented production, the country's pulses sown area reached 2.68 million hectares in 1999～2000 and the export volume were from 17 thousand metric tons in 1988～89 to 650 thousand metric tons in 1999～2000.

The agricultural cooperation introduced the new pulses technology to farmers in 1974. Most suitable cultivators are selected through breeding program and collaborative research activities with ACRISAT. Pulses have been listed as a new crop in this scheme and Myanmar was designated as a leading country for the pulses development in ASEAN countries.

In Myanmar, pulses production depends on weather and soil fertility, more specially on rainfall and availability of chemical and natural fertilizers. Generally, modern variety response on chemical fertilizers and water control.

The agricultural cooperation has introduced locally improved varieties with higher yield potentials. The changes in pulses yields are attributed to the introduction of HYVs and production increases are almost entirely attributed to higher yields as there has been little or no change in planted area. More than 43% of total pulses area is now planted to HYVs. The rate of expansion was gradual in the beginning, but it increase at the rate of 6.8% per year until 1995. The rate of expansion is slow down after ward.

The modern varieties and fertilizers were integrated simultaneously in Myanmar agriculture because of the well responsiveness of HYVs to fertilization. The supply of fertilizer was much lower than the amount recommended. Government generally intervenes in pricing farm products to achieve one or a combination of the following objectives;

1) to reduce price and income instability,
2) to improve the allocation of resources,
3) to increase self-sufficiency in food and fiber, and
4) to raise the average level of prices and incomes.

Zuhair A. Hassan(1995)   The government intervenes in the agricultural sector in many, if not all, countries in the world. Reasons for government intervention include the desires to provide farm price and income supports, to ensure food security, to improve the balance of trade, to reduce consumer prices, to address environmental and regional concerns, and to pursue sanitary and phytosanitary objectives.

In the 1980s, concerns about increased government intervention in agriculture were voice more loudly than in earlier decades. At the same time, the unfavorable consequences of agricultural support and protection for commodity markets, the associated high costs incurred by governments and consumers, and the inadequacies of the existing General Agreement on Tariffs and Trade (GATT) rules for agriculture became more widely recognized.

The government procurement price is lower than the free market and international market price. The procurement price of pulses is given by government. Depending on different peas and beans which refer to a specific peas and beans, procurement price varied.

The objectives of setting the price policy are to stabilize the price and to maintain the low prices of essential commodities to consumers. In 1976-77, the procurement system was changed and the official procurement

prices for pulse was almost double to increase the pulses procurement under the new system, farmers have to sell a certain quota to the trade cooperation no.1 at these fixed prices. Any remaining surplus can be sold in the free market within the township.

2.   Problem Statement

In spite of the government's constant encouragement to increase production, it still faces a short fall because of its slow growth. In Myanmar, the problem of inadequate pulses supply has always been a major concern. Likewise, the diffusion of modern pulses production technology among Myanmar farmers proves to a difficult process. The modern pulses production technology, if widely diffused will help farmers become producers-earners and will enable the country's arable land to achieve grater production and productivity.

To design an effective development strategy for pulses production and to establish a good mechanism for setting price and for procuring, and exporting pulses, the government must quantitative information regarding the response of pulses farmers to changes in price of pulses and technology.

An analysis of the factors that contribute to agricultural growth is necessary to establish sound economic policies for the country. In market economies, prices play a major role in promoting agricultural growth. There are at least two different views regarding the responsiveness of farmers to price in developing countries. One is that the degree of responsiveness is very small or does not exist at all. The other is that they are very price-responsive. If the study can show that farmers are responsive to price, changes in production can be accomplished by using prices as and incentive for farmers. On the other hands, if supply is not price-responsive, increase in production can be achieved by changing the underlying technological or social condition under which the crops are produced.

The growth and development of agriculture depend on various factors: natural, economic, technical and institutional. This is the case for Myanmar, one of the most heavily agriculture-based economics whose objective is to be self-sufficient in its national food requirement. Improve knowledge of the sources of growth agriculture would contribute to the rational and efficient allocation of resources or inputs for agricultural development.

In general, this study will consider the development of Myanmar's agriculture with emphasis on the pulses industry.

Under freely competitive market conditions, price plays an important role in affecting agricultural output and influencing the farmer's decisions. In the Myanmar economy where government heavily intervenes in the market, prices may not play any role in the short-run, but it may trend to change in quasi-fixed factors in the long-run. The major objective of this study is to analyze the factors that affect pulses production, particularly the relative roles of prices and technology in regulating the pulses economy.

3. Hypothesis of Study

1) Since pulses price is set by the government, it is hypothesized that the supply response of output with respect to relative price of pulses may be positive and significant that the price elasticity of output is inelastic.

2) The growth in supply of pulse is mainly determined by technological changes and investment in infrastructure which reduce the unit cost of production. Theoretically, If the technological innovation typically results in a downward shift in the cost schedule, implying a rightward shift in the supply schedule of the product. The result can show the development and diffusion of new pulses technology, fertilizer requirement for pulses production will be increased. Thus, it seems reasonable to expect that the new pulses technology will have the effect of increasing the price response of output through adjustments in use of fertilizer and other current inputs. Hence, it is hypothesized that the yield response to MVs and the output response to technology are significant.

4. Simplified Models for the Pulses Economy in Myanmar

This study only cover the response of pulses farmers to change in the price of pulses at the point of production, a discussion of pulses procurement and consumption is appropriate.

A portion of the pulses production is procured by the government as a quota for per farm. The government procurement is determined by the formula which reflects firm size, farm consumption requirement and yield. Of course, average about 40% of the total pulses production is procured and the remainder is divided between home consumption and local free market sales. In fact, the level of total production and level of government procurement price are determining the amount procured and the surpluses available for pulses export and foreign exchange earning.

4.1. Conceptual Models for Supply Response Function

The output of pulses for any time period may be defined as the product of area and yield. The desired area can be regarded as dependent on the expected levels of the following variables: the price of pulses, the pulses technology, the irrigation infrastructure, and weather condition. That is

$$A^*_t = f_2(Pf^*_t, P^*_f, I^*_t, T^*_t, W^*_t) \qquad (1)$$

Also the expected yield is assumed to be a function of several variable. Thus,

$$Y^*_t = f_3(Pf^*_t, P^*_f, I^*_t, T^*_t, W^*_t) \qquad (2)$$

where,

Y^*_t = expected yield in period "t",

P^*_t = expected price of pulses in period "t",

P^*_f = expected price of fertilizer in period "t",

I^*_t = expected irrigated area in period "t", and

T^*_t = expected pulses technology in period "t".

Statistical Models of Pulses Response Function

The logarithmic form may be used on area response function,

$$LnA^*_t = \beta_0 + \beta_1 LnPf^*_t + \beta_2 LnT^*_t + \beta_3 LnI^*_t + \beta_4 LnW^*_t + \mu_t \qquad (3)$$

When "ln" is the logarithmic transformation of the dependent and independent variables.

A^*_t = Expected pulses area at period "t",

Pf^*_t = Expected fertilizer price of pulses at period "t",

T^*_t = Expected level of pulses technology at period "t",

I^*_t = Expected irrigated area at period "t",

w^*_t = Expected weather condition at period "t", and

μ_t = Residual term.

The following assumption might be hold for the area function, (1) the expected fertilizer price in period "t" is projection of price during the previous period, that is, $Pf^*_t = Pf_{t-1}$; (2) the expected technology in period "t" is the same as the actual pulses technology existing in the current period, $T^*_t = T^*_{t-1}$; (3) the expected irrigation in period "t" is the same as the actual irrigation in the current period, $I^*_t = I^*_{t-1} =$; (4) the expect weather condition is the same as the actual condition in the current period, $W^*_t = W^*_{t-1}$, Using these assumption, equation (6) might be express as:

$$LnA^*_t = \beta_0 + \beta_1 LnPf^*_t + \beta_2 LnT^*_t + \beta_3 LnI^*_t + \beta_4 LnW^*_t + \mu_t \qquad (4)$$

The relationship between planned and actual pulses area may be adjusted hypothetically by the Nerlovian adjustment model.

Yield response function

In equation (3), it was assumed that expected pulses yield is a function of the expected price of pulses, the expected fertilizer price, the expected irrigated area, the expected pulses technology and expected weather condition. Expressing their functional relation in logarithmic form, the yield response function may be expressed as:

$$LnY^*_t = \gamma_0 + \gamma_1 LnP^*_t + \gamma_2 LnPf^*_{t-1} + \gamma_3 LnI^*_t + \gamma_4 LnT^*_t + \gamma_5 LnW_t + \mu_t \qquad (5)$$

Where "ln" is the logarithmic transformation of the dependent and independent variables. " μ_t " is the residual term. If the assumption made for area response function also hold for the yield response function, then using these assumption, equation (6) may be expressed as,

$$LnY^*_t = \gamma_0 + \gamma_1 LnP_t + \gamma_2 LnPf_{t-1} + \gamma_3 LnI_t + \gamma_4 LnT_t + \gamma_5 LnW_t + \mu_t \qquad (6)$$

Since the farmers are unable to equate the actual yield to expected yield, it should be considered with regard to the expected yield. The major causes that actual yield to diverge from the expected yield may be due to (1) the weather condition during the production period; (2) the farmers could not employ fully the level of inputs that

they desire; (3) the existing uncertainties in pulses production. In this case, the relationship between expected yield and actual yield may be expressed as:

4.2.   Conceptual Models For Growth Decomposition Model

In Myanmar agricultural sector, the quasi-fixed inputs that affect the implementation of technology, tend to change the agricultural productivity in the long run. The quasi-fixed inputs used here is represent the government investments on irrigation facilities, research and extension expenditure, fertilizer, and the physical infrastructure such as roads.

The model is derived from the postulate of the government expectation. This definition of expectation from the government's perspective utilizes time trends and presuppose that the government has information on the areas planted separately to the high-yielding and traditional varieties of rice, which it uses to forecast "average" yields(average of the two varieties). Subsequently, the forecasting process is hypothesized to be based on the proportion of the total rice area planted to each variety- the two proportions being trended. That is,

$$E(Y)=f[t(HYV),t(1-HYV)] \qquad (7)$$

Where, "Y" denotes the "average" yield of rice, "t" the year, and "HYV" and "(1-HYV)" the proportions of the total rice area planted to the high-yielding and traditional varieties, respectively (Bindlish, Barker and Mout, 1989).   In this hypothesis it is argued that, before the HYVs were introduced, the government's expectation were only a function of "t[HYV=0 and (1-HYV)=1]". However, since their introduction, these expectations have become a function of weighted trend the weights being the proportional shares of the high-yielding and traditional varieties in the total rice area.

4.3.   Statistical Models

Fertilizer nutrients and rainfall, irrigated and unirrigated area HYV are all clearly potentially important determinants of pulses output. Thus, it is reasonable to assume that the high-yielding and traditional varieties of pulses are characterized by different production functions. Time series framework is the following.

$$Q_t = [\gamma_0 + \lambda_1 P_{t-1} + \gamma_2 I_t + \gamma_3 N_t + \gamma_4 N_2 t + \gamma_5 R_t]HYV$$
$$+ [\phi_0 + \phi_1 P_{t-1} + \phi_2 I_t + \phi_3 N_t + \phi_4 N_2 t + \phi_5 R_t]*(1-HYV) + \mu_t \qquad (8)$$

This specification assumes that the same inputs are used with both varieties but that these inputs interact differently with each variety. The specification entails combining two regressions in which the proportional shares of the two varieties in a total rice area each year "HYV" and "(1-HYV)" are employed as weights. Interactions are then specified between the respective weights for the two varieties and the other inputs. For the growth in rice production, separate area and yield functions were estimated rather than a single output function.

$$AREA_t = [\alpha_0 + \alpha_1 P_{t-1} + \alpha_2 I_t + \alpha_3 R_t]HYV$$
$$[\beta_0 + \beta_1 P_{t-1} + \beta_2 I_t + \beta_3 R_t](1-HYV) + \mu_t \qquad (9)$$

$$YIELD_t = \left[\vartheta_0 + \vartheta_1 N_t + \vartheta_2 N^2 t + \vartheta_3 R_t + \vartheta_4 R_t N_t\right]HYV$$
$$\left[\gamma_0 + \gamma_1 N_t + \gamma_2 N^2 t + \gamma_3 R_t + \gamma_4 R_t N_t\right](1-HYV) + \mu_t \qquad (10)$$

where,

Q_t = Total output of pulses in year "t",

$AREA_t$ = Total pulses growing area in year "t"(ha),

$YIELD_t$ =   Average pulses yield in year "t"(kg/ha),

HYV_t = Proportion pulses area planted to HYVs is in   year "t",

I_t = Irrigated pulses area in year "t",

N_t =   Total nitrogen use for pulses in year "t" (t/ha),

R_t = Annual rainfall in year "t"(mm), and

$\varepsilon_t, \mu_t, \upsilon_t$ = Error terms.

Area and yield were specified as the weighted sum of the separate area and yield of HYV and non-HYV varieties. The same input variables enter both components of the area and yield functions. In effect, what this specification assumes was that although the same inputs are used for both varieties, in terms of the response these inputs interact differently with each variety.

From the results, the elasticities of area, yield and production with respect to the explanatory variables were reported. The production elasticities was derived from the area and yield elasticities using the relation:

$$E^Q{}_x = E^A{}_x + E^Y{}_x \qquad (11)$$

where "x" denotes any explanatory variable of interest.

4.4. Decomposition of the Sources of Growth

To calculate the sources of change in area and yield, expanding and collecting terms, equation (2) and (3) were simplified as follows:

$$AREA_t = (\alpha_0 - \beta_0)HYV + (\alpha_1 - \beta_1)P_{t-1}(HYV) + (\alpha_2 - \beta_2)$$
$$I_t(HYV) + (\alpha_3 - \beta_3)R_t(HYV) + \beta_1 P_{t-1} + \beta_2 I_t + \beta_3 R_t + \beta_0 \qquad (12)$$

$$YIELD_t = (\vartheta_0 - \gamma_0)HYV + (\vartheta_1 - \gamma_1)N_t(HYV) + (\vartheta_2 - \gamma_2)$$
$$N^2{}_t(HYV) + (\vartheta_3 - \gamma_3)R_t + (\vartheta_4 - \gamma_4)R_t N_t(HYV) + \gamma_1 N_t \qquad (13)$$
$$+ \gamma_2 N^2{}_t + \gamma_3 R_t + \gamma_4 R_t N_t + \gamma_0$$

Let denote the change in a variable between pre-HYV and post-HYV periods, then the change in area and yield could be derived from the changes in bthe explanatory variables as follows;

$$AREA_t = (\alpha_0 - \beta_0)\Delta HYV + (\alpha_1 - \beta_1)(P_0 \Delta HYV + \Delta P \Delta HYV) + (\alpha_2 - \beta_2)$$
$$(I_0 \Delta HYV + \Delta I \Delta HYV) + (\alpha_3 - \beta_3)(R_0 \Delta HYV + \Delta R \Delta HYV) + \beta_1 \Delta P + \beta_2 \Delta I + \beta_3 \Delta R \qquad (14)$$

$$YIELD_t = (\vartheta_0 - \gamma_0)\Delta HYV + (\vartheta_1 - \gamma_1)(N_0 \Delta HYV + \Delta N \Delta HYV) + (\vartheta_2 - \gamma_2)$$
$$(N_0{}^2 \Delta HYV + \Delta N^2 \Delta HYV) + (\vartheta_3 - \gamma_3)(R_0 \Delta HYV + \Delta R \Delta HYV) + (\vartheta_4 - \gamma_4)$$
$$(R_0 N_0 \Delta HYV + R_0 \Delta N \Delta HYV + N_0 \Delta R \Delta HYV + \Delta N \Delta R \Delta HYV) + \qquad (15)$$
$$\gamma_1 \Delta N + \gamma_2 \Delta N^2 + \gamma_3 \Delta R + \gamma_4 (R_0 \Delta N + N_0 \Delta R + \Delta N \Delta R)$$

Sources of change in area and yield in time-series model could be grouped as follows;

Sources	Change in area	Change in yield
Change in varieties	$\begin{bmatrix} (\alpha_0 - \beta_0) + (\alpha_1 - \beta_1)P_0 \\ (\alpha_2 - \beta_2)I_0 + (\alpha_3 - \beta_3)R_0 \end{bmatrix}\Delta HYV$	$\begin{bmatrix} (\vartheta_0 - \gamma_0) + (\vartheta_1 - \gamma_1)N \\ + \vartheta_2 - \gamma_2)N_0{}^2 + \\ \vartheta_3 - \gamma_3)R_0 + (\vartheta_4 - \gamma_4)R_0 N_0 \end{bmatrix}\Delta HYV$
Change in nitrogen use	-	$(\vartheta_4 - \gamma_4 R_0)\Delta N + \gamma_2 \Delta N^2$
Change in lagged price	$\beta_1 \Delta P$	-
Change in irrigated area	$\beta_2 \Delta I$	-
Change in rainfall	$\beta_2 \Delta R$	$(\gamma_3 + \gamma_4 N_0)\Delta R$
Interaction between change in nitrogen and HYV	-	$\begin{bmatrix} (\vartheta_1 - \gamma_1) + (\vartheta_4 - \gamma_4)R_0 \end{bmatrix}$ $\Delta N \Delta HYV + (\vartheta_2 - \gamma_2)$ $\Delta N^2 \Delta HYV$
Interaction between change in rainfall and nitrogen	-	$\gamma_4 \Delta R \Delta N$
Interaction between change in rainfall and HYV	$(\alpha_3 - \beta_3)\Delta R \Delta HYV$	$\begin{bmatrix} (\vartheta_3 - \gamma_3) + (\vartheta_4 - \gamma_4)N_0 \end{bmatrix}$ $\Delta R \Delta HYV$
Interaction between change in nitrogen, rainfall and HYV	-	$(\vartheta_4 - \gamma_4)\Delta R \Delta N \Delta HYV$
Interaction between change in price and HYV	$(\alpha_1 - \beta_1)\Delta P \Delta HYV$	-
Interaction between change in irrigation area and HYV	$(\alpha_2 - \beta_2)\Delta I \Delta HYV$	-

The sources of change in production were derived from the relation:

$$\Delta Q = A_0 \Delta Y + Y_0 \Delta A + \Delta Y \Delta A \qquad (16)$$

5. EMPIRICAL FINDINGS

5.1. Area Response Function

The results of estimation of area response functions are summarized in Table 1. The equations are presented in the form of the distributed lag model.

The model seems to fit the data in all equations. The coefficient of determination range from 0.82 to 0.86 and explanatory power of the model increased when the time trend variable was added.

The regression coefficient of HYV is not significantly affected in all area response functions. It may be due to the situation that Myanmar is now in its "closing cultivation frontier" era. It is seen in equation 5 and 6 that time as an explanatory variable significantly affected the area at the 1% level. The growth rate of area has steadily increased from 0.2 to 0.4% every year due to externality variables such as shift to competitive crops and other uses. The input (urea fertilizer) price and irrigated area of pulses significantly affect alternative of land as shown by value of the regression coefficients of these variables in equation 6. The result shows that as investment in irrigation facilitated the opening up of news technology for pulses cultivation.

The coefficient of rainfall and lagged area planted (A_{t-1}) are highly significant in all equations. It shows the dependence of Myanmar pulses production on weather conditions and on the government's agricultural development plan.

This area response study indicates that input fertilizer price affected on the area response, agricultural development plan and agro climatic conditions and modern technology had significant influences.

Table 1. Estimate area response function (log linear form)

Variable	Equation number					
	1	2	3	4	5	6
R^2	0.82	0.83	0.82	0.84	0.88	0.86
D.W	1.84	1.63	1.60	1.98	1.67	1.50
Constant	0.82 (0.83)	1.36 (1.02)	1.21 (0.87)	0.68 (0.80)	2.10** (0.90)	2.50*** (0.91)
P_{ft-1}	-0.02 (0.01)	-0.004 (0.01)		-0.02** (0.01)	-0.02* (0.009)	-0.03*** (0.02)
IRGN		0.05 (0.06)	0.07 (0.05)		0.15** (0.06)	0.16*** (0.05)
HYV	-0.001 (0.001)		-0.003 (0.0008)	0.0001 (0.001)		0.007 (0.0008)
RAIN	0.22*** (0.05)	0.021*** (0.05)	0.021*** (0.05)	0.20*** (0.05)	0.17*** (0.05)	0.15*** (0.05)
AT_{-1}	0.70*** (0.08)	0.61*** (0.13)	0.062*** (0.11)	0.74*** (0.08)	0.49*** (0.12)	0.45*** (0.12)
TIME				0.002* (0.001)	0.004*** (0.001)	0.002*** (0.0009)

Note : 1) Figure in parentheses are standard error.

2) *** = significant at 1% level   ** = significant at 5% level   * = significant at 10% level

5.2.   Yield Response Function

The result of yield response function is shown in Table 5. When lagged yield was included in the equation, the function became inconsistent and biased. A multicolinearity problem was also found among explanatory variable due to the close interrelation among modern inputs, HYV, Irrigation, and chemical fertilizer which are part of the package of the new technology. To avoid this problem proportion of irrigated area to total irrigated area and the proportion of HYV sowing area to total pulses area used as alternate explanatory variables in the separate equations.

In 'equation 1' pulse and fertilizer price variables have right signs and are significant at the 5% and 1% level respectively. In 'equation 2' when urea price was eliminated, the pulse price is not significant at all. These finding indicate that procurement price would be affect yield response only with efficient input subsidy.

HYV is highly significant in all equations. IRGN and Rainfall variables are significant in three equations. Fertilizer variable is highly significant in 'equation 4'. The yield response study indicates that the technology package and weather conditions are major determinants of increase in yield. Coefficient of determinant is range from 0.51 to 0.80. In regression 6, using only input and output price, both pulses price and fertilizer price are highly significant, but it had a low R^2 and D.W. The regression using only technology variables such as HYV, RAIN, and FRT as explanatory variables had the coefficient of determination with a value of 0.80. Therefore, yield may be affected mostly by technology variables. The result of the analysis using principle component regression methods are also shown in Table 2.

Table 2. Estimated yield response function (log linear form)

Variable	Equation Number						
	1	2	3	4	5	6	PC
R^2	0.68	0.52	0.58	0.80	0.51	0.57	0.67
D.W	1.91	1.07	1.29	1.19	1.17	1.56	0.86
Constant	7.69*** (0.21)	7.56*** (0.25)	7.74*** (0.24)	8.30*** (0.19)	7.60*** (0.24)	7.49*** (0.22)	7.65 (0.21)
P_{rt}	0.17*** (0.06)	0.04 (0.06)				0.16*** (0.05)	0.097 (0.02)
Pft-1	-0.22*** (0.06)		-0.11** (0.05)			-0.20** (0.05)	-0.057 (0.01)
IRGN	0.02 (0.04)	0.11*** (0.03)	0.09*** (0.03)		0.12*** (0.03)		0.039 (0.009)
HYV	0.05** (0.02)	0.06*** (0.02)	0.07*** (0.02)	0.05*** (0.01)	0.07*** (0.02)		0.023 (0.008)
RAIN	0.04 (0.04)	0.09** (0.04)	0.09** (0.04)	0.02 (0.03)	0.10** (0.04)	0.05 (0.04)	0.07 (0.01)
FRT				0.14*** (0.02)			0.055 (0.008)

Note: 1) Figure in parentheses are standard error.

  2) *** = significant at 1% level   ** = significant at 5% level *   = significant at 10% level

5.3 Growth Decomposition Model

Assuming there was no HYV sown area up to 1982, separate area and yield functions were estimated. In the area function, pulses planted area (AREA) was dependent variable and explanatory variables used here were; lagged price of pulses deflated by wholesale price index (P_{rt-1}), irrigated pulses area (IA), average annual rainfall(R), and proportion of area planted to MVs (HYV), and proportion of area planted to traditional varieties (1-HYV). In the yield function, dependent variable was yield per hectare(Y) and the independent variables were nitrogen use for pulses crop (N) and average annual rainfall(R).

   Since there were server multicollinearity problems, the principle component regression package was used to obtain reasonable results. The following results were obtained (figure in parentheses are t-statistics);

$$AREA = [627.615 + 16.1915IA_t - 0.19R_t + 4.182P_{-1}]HYV$$
$$(13.477)(8.918)(-2.522)(7.673)$$
$$+ [584.686 + 16.079IA_t - 0.191R_t + 4.222P_{-1}](1 - HYV) \qquad (17)$$
$$(3.123)(8.984)(-2.518)(8.317)$$
$$R^2 = 0.978$$

$$YIELD = [458.837 + 13.00N_t - 0.176N^2_t - 0.0058R_t + 0.00098R_tN_t]HYV$$
$$(1.121)(0.811)(-1.204)(-0.333)(0.187)$$
$$[811.101 - 1.979N_t - 0.0012N_t^2 - 0.069R_t + 0.0031R_tN_t](1 - HYV) \qquad (18)$$
$$(1.972)(-0.125)(0.008)(-0.417)(0.628)$$
$$R^2 = 0.594$$

5. 4   Decomposition of the Sources of Growth

Expanding and collecting terms, equation (17) and (18) could be simplified as follows:

$$AREA = 42.83HYV_t + 0.116IA_tHYV_t - 0.003R_tHYV_t - 0.04P_{-1}HYV_t$$
$$+ 16.079IA_t - 0.191R_t + 4.222P_{-1} + 584.686 \qquad (19)$$

$$YIELD = -352.264HYV_t + 14.979N_tHYV_t - 0.1772N_t^2HYV_t$$
$$+ 0.0632R_tHYV_t - 0.0021R_tN_tHYV_t - 1.979N_t + 0.0012N_t^2 \qquad (20)$$
$$- 0.069R_t + 0.0031R_tN_t + 811.101$$

   Denoting the change in a variable between pre- and post new pulses technology periods by " ", then the change in area and yield can be derived from the change in the explanatory variables in the above equations as follows;

$$\Delta AREA = 42.83\Delta HYV + 0.116(IA_0\Delta HYV + \Delta IA\Delta HYV)$$
$$- 0.003(R_0\Delta HYV + \Delta R\Delta HYV)$$
$$- 0.04(P_0\Delta HYV + \Delta P\Delta HYV) \qquad (21)$$
$$+ 16.079(\Delta IA - 0.191\Delta R + 4.222\Delta P)$$

$$\Delta YIELD = -352.26\Delta HYV + 14.979(N_0\Delta HYV + \Delta N\Delta HYV)$$
$$- 0.1772(N_0^2\Delta HYV + \Delta N^2\Delta HYV)$$
$$+ 0.0632(R_0\Delta HYV + \Delta R\Delta HYV)$$
$$- 0.0021(R_0N_0\Delta HYV + R_0\Delta N\Delta HYV + N_0\Delta R\Delta HYV + \Delta R\Delta N\Delta HYV) \qquad (22)$$
$$- 1.797\Delta N + 0.0012\Delta N^2 - 0.069\Delta R$$
$$+ 0.0031(R_0\Delta N + N_0\Delta R + \Delta N\Delta R)$$

Where the zero subscript denotes the value of the variable in the pre-new technology period and assuming that no HYVs were grown in that period ($HYV_0 = 0$). The terms on the right hand side of the equation (21) and (22) could be grouped according to the sources of change, as shown in Table 3. The result in Table 4 was obtained. The sources of changes in production were obtained from the equation:

$$\Delta Q = A_0\Delta Y + Y_0\Delta A + \Delta A\Delta Y \qquad (23)$$

 The change in price is a major source of change in area. The result shows that due to a 1 unit change in price, the area was increased by 0.6 units. Change in variety has positive effect on change in area. A 1 unit

adoption of MVs resulted in a increase of 0.03 units of area. It shows that when production and yield increase due to adoption of MVs, area was shifted to other crops. The same result is shown in the interaction between change in price and variety.

The results show that the adoption of HYVs and use of nitrogen fertilizer were the major sources of growth in pulses production in Myanmar between the pre and post new technology periods. Although HYVs had positive effect on the increase in area, it contributed to 68% increase in yield. These findings shows that as HYVs increase pulses yield, the need for pulses could grow with more land cultivated to other crops. So land was diverted from pulses to other crops. The adoption of HYVs accounted for 56% of the increase in production.

Table 3. Sources of change in area and yield

Sources	Change in Area	Change in Yield
Change in varieties	$(42.83 - 0.04P_0 + 0.116IA_0 - 0.003R_0)\Delta HYV$	$(-352.26 + 14.979N_0 - 0.1772N_0^2 + 0.0632R_0 - 0.0021R_0N_0)\Delta HYV$
Change in nitrogen use	-	$(-1.979 + 0.0031R_0)\Delta N + 0.0021\Delta N^2$
Change in lagged price	$4.22\Delta P$	
Change in Irrigation	$16.079\Delta IA$	
Change in annual rainfall	$-0.191\Delta R$	$(-0.069 + 0.0031N_0)\Delta R$
Interaction between changes in nitrogen use & varieties		$(14.979 - 0.0021R_0)\Delta N\Delta HYV - 0.1772\Delta N^2\Delta HYV$
Interaction between changes in rainfall and nitrogen use		$0.0031\Delta N\Delta R$
Interaction between rainfall and varieties	$-0.0031\Delta R\Delta HYV$	$(0.0632 - 0.0021N_0)\Delta R\Delta HYV$
Interaction between changes in nitrogen use, rainfall & varieties		$-0.0021\Delta R\Delta N\Delta HYV$
Interaction between changes in lagged price & varieties	$-0.04\Delta P\Delta HYV$	
Interaction between changes in irrigation and varieties	$0.116\Delta IA\Delta HYV$	

Table 4. Decomposition of sources of change in area, yield and production (%)

Source	Change in area	Change in yield	Change in production
Change in variety	3.10	68.68	56.11
Change in nitrogen use		88.91	43.22
Change in lagged price	60.32		57.16
Change in irrigation	23.98		18.87
Change in rainfall	12.46	-17.58	-13.19
Interaction between change in nitrogen use and variety		21.15	28.23
Interaction between change in rainfall & nitrogen use		-34.42	-29.14
Interaction between change in rainfall and variety	-0.12	-11.69	-32.18
Interaction between change in rainfall, nitrogen & variety		-15	-29.16
Interaction between change in lagged price and variety	0.36		0.22
Interaction between change in irrigation and variety	-0.11		-0.14

Additional irrigation facility had its impact on the expansion of area planted to pulses. The interaction effect of additional irrigated area and HYVs on production was negative. This effect arises from changes in planted area, showing that when irrigation facility was developed along with HYVs, some land were diverted to other crops.

Increased nitrogen use had a high positive effect on yield, accounted for 88% of increase in yield and 43% of the increase in production. The interaction effects of nitrogen and HYVs on yield and production were positive but give a small contribution for pulses production.

The interaction of rainfall and nitrogen, Likewise, interaction effect of rainfall and HYVs and interaction effect of rainfall, nitrogen, and HYVs had negative effect on yield and production. This suggests that HYVs and nitrogen are not suitable for rainfed areas in Myanmar.

Price movement had a positive impact on area and production and interaction between price and HYVs had positive effect. It shows that the change in government procurement system resulted in an increase in area and production. The lagged price deflated by wholesale price increased from a period means of 6 in 1970～1982 to 121 in 1983～2000.

6. CONCLUSIONS

In this study, it is seen that fertilizer prices have only a marginal role to play and other agro climatic conditions are more important. This study suggests that efficient pricing policy in the pulse economy to increase pulse production.

On the other hand, annual agricultural plans and institutional factors such as agricultural research, extension, and more investment in irrigation facilities could significantly influence yield and production.

The growth decomposition study shows the effect of the new pulses technology on yield and production. If the government could invest a larger amount for price development, the area planted to pulses will further increase and effect on production would be higher than it tries to manipulate prices.

Changes in fertilizer use and adoption of HYVs had major impact on increase in yield, and interaction among changes in HYVs, nitrogen, and rainfall shows that such interaction was not suitable in rainfed areas. It is suggested that modern inputs like high-yielding seeds and chemical fertilizers can increase yield and production with irrigation system. A major limitation of the present study is that used the national level data which limited the degree of freedom. There is a need to undertake further studies using pooled regional level cross-section time series data.

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