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AN ASSESSMENT OF YIELD CONSTRAINTS AND QUANTIFICATION OF ECONOMIC SURPLUS OF PADDY IN TAMIL NADU, INDIA

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Abstract: *Rice is grown extensively in Tamil Nadu. About 94% of total area under rice in the State is concentrated in high productivity group, which accounts for about 98% of total production of rice in the State. Rice production in Tamil Nadu is constrained by insects, disease and mis-management practices. This paper analysis the constraints and assessing the economic surplus in relation with different technologies used in paddy production. The respondents, 560 rice farmers,560 rice consumers, 120 scientists engaged in rice research and equal number of extension personnel, provided estimates of yield loss due to each constraint for their respective agro-climatic zones in Tamil Nadu. There are 37 constraints, which have economic significance, were identified. The total losses due to all constraints worked out to about 1.14 million tonnes, which is 63 per cent of the total production. There exists a 60 per cent potential to increase the productivity of rice. The total losses in absolute terms are highest in cauvery delta zone, since this zone leads in the production also. The loss due to leaf folder is the maximum in the state accounting for 11.40 percent of the total losses. . The economic surplus for leaf folder was the maximum which amounted to Rs. 169.01 million. The Benefit Cost analysis revealed that biotechnology is economically profitable for solving the constraints.*

Keywords: *Total losses, constraints, Economic surplus, Benefit-cost analysis, Production.*

Introduction

Rice is the staple food for most of Indian population and particularly for southern and eastern Indians. There has been a giant leap in rice productivity and production in 80's and 90's after the introduction of high yielding, short duration and photo insensitive varieties**.** India has revealed that 2015-16 kharif (June - December) rice production is at around 90.6 million tons, which is slightly less from around 90.86 million tons of production in 2014-15 (Rice outlook, 2015). Increases in the area of rice cultivation, generation of improved rice production technologies were the major influencing factors behind the increase in rice production which has matched the demand from growing population. However, trend in rice in India over the recent year's scenario is changing. Current growth rate in production does not keep pace with the growth in population. Apparently, rice production has come to stagnation in recent years due to many constraints. With almost no hope for increasing area under rice production, only way out for production increment is to increase the productivity of rice lands in future.

Hence there is a strong case to identify the constraints which operate to keep rice yields significantly below their potential maximum and to channelise efforts to increase yield by solving the constraints particularly in the low yield regions and in the farms with low yield within given regions. Recently, positive impact of the technology was reflected in improvement in productivity, high benefit-cost ratio and increase in social welfare. The massive agricultural research and technology transfer effort of the 1960s and 1970s, often referred to as the 'green revolution', led to dramatic increases in agricultural productivity. Smallholders in developing countries, especially in Asia and Latin America, benefited substantially from these advances in agricultural research as well as from strong extension services (Ellis F, 2005).

Primary nutritional impact for the poor came through the increased food supplies generated through technological change. Further, the profitability of modern farming systems has been maintained despite falling food prices (in real terms), owing to a steady decline in the cost of production.

Several empirical evidences show quite clearly that the cost of production has fallen significantly in the case of rice and many of the crops. Consistently, unit production costs have tended to decline over time, and over the same period, production costs have generally tended to be lower than output prices in the State. In this aspects, this paper analysis the constraints and assessing the economic surplus in relation with different technologies used in paddy production.

Objectives of the study

1. Identifying and quantifying the productivity constraints causing yield losses in rice.
2. Analyzing the economic impacts of rice research and technologies in solving the quantified constraints

Data and Methodology

Agricultural research programs have different implications on economic growth, food security and income distribution of the rural people. Agricultural research systems have a mandate to transfer information and technology to producers both geographically and between different farm size groups.

Sample Size

Purposive random sampling technique has been employed in selecting Rice farmers and Rice consumers. The district is considered as a basic sampling unit. In each district 20 Rice farmers and 20 Rice Consumers were selected randomly comprising a total sample size of 560 farmers and equal number of consumers. The respondents, 560 rice farmers, 560 rice consumers, 120 scientists engaged in rice research and equal number of extension personnel, provided estimates of yield loss due to each constraint for their respective agro-climatic zones. The International Maize and Wheat Improvement Center (CIMMYT) (Gibbon *et al*., 2007) interviewed panelists with regional expertise for 12 of the 15 food-insecure and drought-prone farming systems highlighted byto identify the top ten production constraints for maize cultivation in each of the farming systems.The yield loss indicated by them is when the constraint is occurring beyond economic threshold level and atleast moderately severe. Only the constraints causing major production losses were analyzed and discussed for the six rice producing zones surveyed. The study considered productivity constraints that occurred between 2010 and 2014.

The whole lot of constraints will include biotic and abiotic factors that limit rice yields.

We categorize the technical constraints as:

- Insects and pests
- Diseases
- Management Constraints

Methodology Framework in the Present Study

Herdt and Capule (1983) proposed a modified NPV approach, and adopted by Ramasamy, Shanmugam and Carl Pray (1997) .The steps which are implemented in the present study, are detailed below.

Estimation of Net Present Value (NPV) and Benefit Cost Ratio (BCR)

Present worth of net benefits of a research project is obtained by deducting present worth of research costs from the present worth of research benefits. It may be interpreted as the present worth of net benefit stream generated by the research investment in solving the constraints to higher rice yield.

Mathematically,

$$NPV = \sum_{t=1}^{t=n} \frac{B_t}{(1+i)^t} - \sum_{t=1}^{t=n} \frac{C_t}{(1+i)^t}$$

Where,

B_t = benefit obtained by solving each constraint in years't'. This is calculated by multiplying annual production loss due to each constraint in the zone by price of rice in years't'.

C_t = research and extension cost allocated for undertaking research project to solve each constraint and extension cost allocated for dissemination of technology emerged out of research efforts in year't'.

n = number of years, research expenses incurred to solve each constraint and number of years in which benefit would flow due to solving constraints. Research costs are incurred for the first 5 - 6 years. During that period, benefits are assumed

to be zero. Benefits may accrue for infinite number of years after research accomplishment. But it is limited to 5 – 6 years here considering it as a reasonable period of time. During the period of benefit flow extension costs are incurred for transmitting technologies.

i = discount rate or the opportunity cost of capital.

The research project which have positive NPV can be identified and prioritized. Possibly a given production constraint can be addressed by many research alternatives with different NPVs. Also the same research alternatives may have differential impact across rice production ecologies. In situation where resources are scarce and projects are mutually exclusive, the NPV will be more appropriate measure than BCR as the net benefits are arrived in absolute amount.

Benefit - Cost Ratio (BCR)

It is the ratio obtained when the present worth of benefit stream of a project is divided by the present worth of research cost stream. Had BCR worked out to be greater than one, then present worth of research would have exceeded present worth research costs. The constraints which have BCR greater than one could be identified and prioritized.

$$BCR = \frac{\sum_{t=1}^{t=n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{t=n} \frac{C_t}{(1+i)^t}}$$

The B_t, C_t, n and i are as explained above.

Estimation of Economic Surplus

Economic surplus model of Alston *et.al* (1995) was used to measure the change in total surplus in a closed economy framework. This model consists of demand and supply equations .In order to estimate the factors influencing demand, the following model has been specified. In this equation the price elasticity of demand has been worked out.

Demand Function

$$\mathbf{Ln\ D = Ln\alpha_0 + \alpha_1 Ln\ x_{11} + \alpha_2 Ln\ x_{12} + \alpha_3 Ln\ x_{13} + \alpha_4 Ln\ x_{14+}\ u_1}$$

Where,

D = Per capita consumption in Kgs per annum

X_{11}= Price per KgX_{12}=Income per annum in Rupees.

X_{13}= Family size

X_{14}= Educational level of housewife

In order to estimate the factors determining the supply the following equation has been specified. In this equation the price elasticity of supply has been worked out.

Supply function

$$\mathbf{Ln\ S = Ln\ \beta_0 + \beta_1 Ln\ x_{21} + \beta_2 Ln\ x_{22} + \beta_3 Lnx_{23} + \beta_4 Ln\ x_{24+}\ u_2}$$

Where,

S = Quantity Marketed per farm Kgs per annum

X_{21} = Price per Kg

X_{22} = Share of acreage under irrigation

X_{23} = Area under Rice in hectares

X_{24} = Rainfall in m.m

Change in Total Surplus = $K_t P_0 Q_0 (1+0.5 Z_t \alpha_1)$

Where,

$\mathbf{Z_t = K_t (\beta_1 / (\beta_1 + \alpha_1))}$

K_t = Vertical Shift in supply function

β_1 = Price elasticity of supply

α_1 = Price elasticity of demand

P_0 = Base year output price

Q_0 = Base year output Quantity

Results and Discussion

Rice is grown extensively in Tamil Nadu. About 94% of total area under rice in the State is concentrated in high productivity group, which accounts for about 98% of total production of rice in the State. Rice is a highly adaptable plant that is grown under different ecological conditions in sub-tropical and tropical regions. However, rice production constraints are more in number. The major constraints in rice production and their magnitude of severity have been identified. (Waddington *et.al.*, 2010) in his analysis also identified the top ten constraints to rice production, which account for only about half of the total rice

yield losses in the South Asian farming systems. The advantage of including the top 24 production constraints is that together, they cover 80%-90% of total rice yield losses, providing a more holistic perspective. With the completion of the initial survey, several aspects of different constraints in Tamil Nadu became clear. Thus, 37 constraints, which have economic significance, were identified (Table 1). It was observed that there were a lot of consistencies in the listing of constraints among the scientists of different agro climatic regions with variations in the ranking depending upon the climatic change.

Table 1: Productivity Constraints of Rice in Tamil Nadu

RICE PESTS	RICE DISEASES
Yellow stem borer	Rice blast
Leaf folder	Brown spot
Ear head bug	Sheath blight
Brown Plant Hopper (BPH)	Sheath rot
Green Leaf Hopper (GLH)	Rice Tungro Virus (RTV)
Thrips	Rice yellow dwarf
Gall midge	Grain discoloration
Whorl maggot	Bacterial Leaf Blight (BLB)
Rodents	**RICE MANAGEMENT**
Cut worm	Drought / Water Scarcity
Case worm	Duration
Rice hispa	Zinc deficiency
Mealy bug	Iron deficiency
Leaf Mite	Imbalanced fertilization
White tip nematode	Aged seedlings
Black bug	Weeds
White Backed Plant Hopper (WBPH)	Salinity
Termite	Lodging / Flooding
Root nematode	Alkalinity

Production Loss

The respondents,560 farmers, 120 scientists engaged in rice research and equal number of extension personnel, provided estimates of yield loss due to each constraint for their respective agro-climatic zones. The yield loss indicated by them is when the constraint is occurring beyond economic threshold level and atleast moderately severe.

Table 2: Production losses due to Insects, Pests and Diseases in Tamil Nadu ('000 tonns)

Loss due to major constraints	CDZ	SZ	NEZ	WZ	NWZ	HRZ	Tamil Nadu
Insects pests	530 (46)	208 (42)	369 (44)	41 (54)	46 (43)	6 (48)	**1202 (45)**
Diseases	282 (25)	120 (24)	225 (27)	17 (23)	29 (27)	3 (27)	**679 (25)**
Management Constraints	334 (29)	163 (33)	242 (29)	17 (23)	33 (30)	3 (25)	**794 (30)**
Total Loss('000T)	1147 (100)	492 (100)	836 (100)	76 (100)	108 (100)	14 (100)	**2676** (100)
Total loss (%)	63	31	47	31	51	16	**47**
Total Production('000T)	1803	1563	1769	240	209	86	**5672**

Cauvery Delta Zone:

The total production of rice in this zone was 1.8 million tonnes.The total losses due to all constraints worked out to about 1.14 million tonnes, which is 63 per cent of the total production. There exists a 60 per cent potential to increase the productivity of rice. The total losses in absolute terms are highest in cauvery delta zone, since this

zone leads in the production also. Of these total losses, insects, diseases and management aspects contributed 46, 24 and 29 per cent respectively. In this region, Leaf folder, blast and lodging are the top most constraints causing maximum yield loss.

Southern Zone

Total rice production of Southern Zone was about 1.56 million tonnes. Of these, the production loss due to all constraints worked out to be about 0.49 million tonnes accounting for about 31 per cent of total production. Insects, diseases and management constraints contributed 42, 24 and 33 per cent of the total production loss respectively. Among insects, leaf folder, yellow stem borer, ear head bug and gall midge are major pests sharing per cent of loss respectively. Rice blast is the major disease causing maximum economic damage in Southern Zone followed by Sheath rot. Among the management constraints, drought/ water scarcity contributes to yield loss.

North Eastern Zone

The total productionin this zone is 1.76 million tonnes.The total losses in north eastern zone were about 0.83 million tonnes and accounts for 47.29 per cent of total production. Insects, diseases and management constraints account for about 44, 26 and 28 per cent respectively. Rice Tungro virus and rice blast is the major disease in north eastern zone of Tamil Nadu. Drought and zinc deficiency are common management problems in North Eastern zone.

Western Zone

The total production in this zone is 0.24 million tonnes. The total loss in the western zone was 0.07 million tonnes, that is, about 31.74 per cent of production. Pests, diseases and management constraints contributed to the production loss by 53.97, 23.42 and 22.58 per cent respectively. Among pests, yellow stem borer is the most serious one followed by leaf folder and ear head bug. Rice blast damage is also high .Among management problems, Zinc deficiency and iron deficiency contributes major share in affecting the yield potential of paddy crop.

North Western Zone

Thetotal production in this zone is 2.09 million tonnes. Total loss incurred in the North Western Zone of TamilNadu by the various constraints is 0.10 million tonnes of grain. This accounts to 55.98 per cent of the total rice production the zone. The loss due to pests, disease and management constraints are 42.64, 26.85 and 30.32 per cent respectively. Among the pests devasting the rice crop, yellow stem borer, leaf folder and ear head bug diminishes the potential yield. Drought, Zinc deficiency and salinity are the most severe in the management constraints in this zone.

High Rainfall Zone

The total production in this zone was 0.86 million tonnes. In the high rainfall zone of Tamil Nadu the yield loss due to the various constraints account to 0.14 million tonnes, this is the least in the state. However this causes 16 per cent reduction in the production. The damage due to pests, diseases and management constraints is in the order of 47, 27 and 24 per respectively. The damage due to pests is the most severe and among them leaf folder, yellow stem borer and ear head bug reduces the production. Damage due to management constraints like lodging/flooding, imbalanced fertilization.

Economic Impact Analysis

The Productivity gains that could be attained by solving constraints through various methods cannot be known with certainty because gains are obtained in the future only after the research is successfully completed. The future research benefits are, therefore, critically determined by the probability of research success. Scientists were asked to suggest alternative research methodologies and costs involved in solving these constraints. The results of the research study show that the top ten constraints need immediate attention by policy makers and agricultural research managers. Scientists were asked to assess the cost of research for two research alternatives viz., biotechnology and conventional breeding methods.

Table 3: Economic Analysis for different Research Methods

Constraint	NPV		BCR		Economic surplus (Million Rs)
	Biotechnology (Million Rs)	Conventional (Million Rs)	Biotechnology (Million Rs)	Conventional (Million Rs)	
Leaf folder	226.53	137.81	26.72	21.49	169.01
Stem borer	183.08	111.76	23.71	17.62	127.30
Drought	152.29	94.42	22.32	15.04	117.90
Rice blast	138.81	83.76	22.56	13.45	108.31
Ear head bug	-	83.50	-	13.41	95.57
Rice Tungro Virus	100.27	59.20	11.44	9.80	76.53
Sheath Rot	88.80	-	10.73	-	66.76
BPH	83.47	47.98	11.86	8.13	63.59
Bacterial Leaf Blight	77.52	44.11	11.76	7.56	57.28

These costs and marginal productivity gains estimated formed the basis to evaluate each problem by each research alternative by computing Net Present Value and Benefit Cost Ratio Analysis. Net Present Value (NPV) and Benefit Cost Ratio (BCR) of the research methods addressing these constraints was worked out and the results are presented in Table 3. We considered only top 10 constraints to prioritize rice research in the state.

NPV for solving first major constraint leaf folder worked out to be Rs.226.53 million and Rs.137.81 million for biotechnology and conventional breeding respectively. NPV for solving the second problem stem borer worked out to Rs.183.08 million for biotechnology and for conventional breeding the value was Rs.111.76 million. The third major constraint was Drought. NPV for biotechnology and conventional breeding was Rs.152.29 million and Rs. 94.42 million respectively. Likewise the NPV values were calculated for all other important constraints. From the table it is noted that biotechnology method is found to be comparatively better than conventional breeding for solving the constraints.

Rice production in Tamil Nadu is constrained by insects, disease and mis-management practices. The loss due to leaf folder is the maximum in the state accounting for 11.40 percent of the total losses. The BCR for leaf folder worked out to be 26.72 and 21.49 for biotechnology and conventional breeding respectively. Following leaf folder, yellow stem borer was the next major constraint identified with a production loss of 9.35 percent. The BCR worked out to 23.71 for biotechnology and for conventional breeding, the ratio was 17.61. The third major constraint was drought; it caused the production loss to the tune of 7.84 percent and the BCR for biotechnology and conventional breeding was 22.32 and 15.04. The loss due to Rice Blast and Ear head bug was 7.14 and 7.12 percent respectively. BCR for Biotechnology and conventional breeding research in solving Rice Blast was 22.56 and 13.45 and for Ear head bug conventional breeding was the only methodology suggested and the BCR was 13.41. Apart from theses, the other constraints those affect the rice crop were RTV, Sheath rot, Brown plant hopper and Bacterial leaf blight in that order. The BC ratio worked out was 11.44, 10.73, 11.86, and 11.76 for biotechnology and 9.80, 8.13 and 7.56 for conventional breeding respectively.

The economic surplus due to research for the various constraints was worked out and is given in Table 13. The economic surplus for leaf folder was the maximum which amounted to Rs. 169.01 million. This is followed by stem borer (127.30), drought (117.90), rice blast (118.31), Ear head bug (95.57), Rice Tungro Virus (76.53), Sheath Rot (66.76), BPH (63.59) and BLB (57.28).

Conclusion

Stepping up rice yields in Tamil Nadu is constrained in a major way by pests, diseases, adverse soils, agronomic and other management problems. The top ten constraints in the state are in the order

leaf folder, yellow stem borer, drought, blast, ear head bug, zinc deficiency, RTV, Sheath rot, BPH and Bacterial leaf blight. The total losses caused by these constraints are 11.40, 9.35, 7.84, 7.14, 7.12, 5.26, 5.20, 4.63, 4.31 and 4.01 per cent respectively which account for a total production loss of 1.7 million tonnes. The results of the research study show that the top ten constraints need immediate attention by policy makers and agricultural research managers. From the table, the Benefit Cost analysis revealed that biotechnology is economically profitable for solving the constraints. Hence it is necessary to make research interventions in these aspects in order to maximize the productivity by minimizing the losses. Alternative technologies which are environmentally less damaging technologies are preferred to replace certain rice production technologies having potential to damage the environment. For example using bio-control agents are preferred in place of chemical to control pests. Such approaches generate benefits beyond those realized in the farmers' field.

References

Alston, J., G.Norton and P.Pardey, 'Science and scarcity", Ithaca: Cornell University press(1995)

Ellis F: Small farms, Livelihood Diversification, and Rural–Urban Transitions: Strategic Issues in Sub-Saharan Africa. 2005, Washington: International Food Policy Research Institute.

Gibbon D, Dixon J, Flores D: Beyond Drought Tolerant Maize: Study of Additional Priorities in Maize. Report to Generation Challenge Program. 2007, 42-Mexico DF, Mexico: CIMMYT

Herdt, R.W. and C.Capule, "Adoption Spread and Production Impact of Modern Rice Varieties in Asia", Los Banos : International Rice Research Institute, 1983.

Ramasamy.C, T.R.Shanmugam and Carl Pray, "Priority Setting for Rice Research in Southern India – An Exante Approach", *Indian Journal of Agricultural Economics,* 52(1), January – March, 1997

Rice outlook, Report series, 2015

Waddington SR, Li X, Dixon J, Hyman G, De Vicente MC: Getting the focus right: production constraints for six major food crops in Asian and African farming systems. *Food Secur.* 2010, 2 (1): 27-48.