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Yield gap analysis of rice cultivation in Kanyakumari district

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Abstract

Agricultural production must be enhanced in an environmentally sustainable manner in the context of increasing competition for water, land and labour, as well as the constantly evolving threat from abiotic and biotic stresses, and under potentially more extreme weather conditions associated with climate change. This study is about the yield gap analysis of different paddy and its variants and to find out the reasons for less productivity in rice in Kanyakumari district. It was found that Yield gap of Rice cultivation in the district was 1135 ka/ac. The Index of Realised Potential Yield (IRPY) of farmers was found to be 68.3% which means that the actual yield achieved by farmers is only 68.3% of the maximum potential yield and that there is untapped potential of 31.7 per cent of yield for rice in the district which we need to enhance through improved production technologies. Yield gap index for major paddy variants ASD 16 was 46.97%, TPS 5 - 31.84 percent and ASD 21- 31.03%. Labour scarcity and high labour charges was a major factor for yield gap in the district.

Keywords: Paddy, rice, paddy variant, yield gap, extension gap and technological index

Introduction

India's food grain output since the 1960s has grown significantly as a result of expanding arable land, large-scale cultivation of high-yielding semi-dwarf varieties, and increasing use of pesticides, fertilizers, and irrigation. India has achieved gross food security during the past three decades as a result of increased food production. However, the growing population in India, is posing a threat to food security. India's population is predicted to increase from its current 1.1 billion to 1.6 billion by 2050. This suggests a higher demand for food. To meet the estimated future demand, agricultural production must be enhanced in an environmentally sustainable manner in the context of increasing competition for water, land and labour, as well as the constantly evolving threat from abiotic and biotic stresses, and under potentially more extreme weather conditions associated with climate change. Despite the fact that there may be enough food for everyone, socioeconomic and political forces would demand for production locally. As there is little scope for easy expansion of agricultural land or irrigation, reducing the 'yield gap has to be accomplished to meet the demand. This study is about the yield gap analysis of different paddy variants and to find out

the reasons for less productivity in rice in Kanyakumari district.

Methodology

Yield gap analysis is a method for estimating the difference between the potential yield of paddy and the average yield achieved on farms. It can help identify the factors that limit yield and improve food production. 'Yield gap', is defined as the difference between potential yield and average on-farm yield obtained by farmers (Saito *et al.*, 2013; van Ittersum *et al.*, 2013) [6, 4]. 'Potential yield' is defined as the maximum yield that can be obtained from a crop in a given environment as often determined by crop simulation models with plausible physiological and agronomic assumptions (Evans and Fischer, 1999) [2]. Under irrigated conditions, potential yield is determined by climate (solar radiation and temperature), varietal characteristics and crop establishment methods, including sowing date and density. The yield gap analysis is carried out in two broad categories, focusing on

1. Quantification of yield gaps and
2. Identification of causes for the yield gaps.

Quantification of yield gaps

Quantification of yield is the first step that was carried out to record the yield of different varieties in rice. Then the areas of higher rice yield is identified and the climatic conduction of the areas are assessed. The first step was to identify areas where large increases in rice yield can be achieved and to quantify yield and yield gap. Furthermore, spatially explicit yield gaps and to assess the reasons for major yield gaps suggest interventions for higher yields. The existing productivity gap is conceptualized as the difference between the highest potential yield that can be obtained in farmers field and the actual farm yield obtained. The yield gap might be due to lag in transfer of technology to farmers and deficiencies in adoption of various technologies by the farmers i.e. inter farm difference in application of technologies. The yield gap exists mainly due to biological and socio-economic constraints.

Computation of yield gaps

International Rice Research Institute method of yield gap analysis was employed. Computation of yield gaps Yield gap was estimated using the methodology developed by the International Rice Research Institute, Manila, Philippines. Various yield gaps were estimated using the following formula

Yield Gap I = Potential Yield - Adaptive Research Trail Yield

Yield Gap II = Adaptive Research Trail Yield - Actual yield

Total yield gap = Yield gap I + Yield gap II

Index of realised potential yield = $[Y_a / Y_p] * 100$

Index of realised potential farm yield = $[Y_a / Y_d] * 100$

Index of yield gap = $[Y_p - Y_a / Y_p] * 100$

Where,

Y_p = Potential Yield (Experimental station yield)

Y_d = Potential Farm Yield

Y_a = Actual Yield realized by the sample farmers

The average paddy yield will be calculated by taking the average of the actual yield recorded in rice fields and the yield gap was calculated.

Extension Gap = Demonstration Yield - Farmers yield

Selection of the study area

The present study will be undertaken for TPS 5 rice variety in Kanyakumari district of Tamil Nadu.

Table 1: Blockwise area under paddy in Kanyakumari district

S. No.	Block	Area (ha)
1	Agastheeswaram	3696.9
2	Rajakkamangalam	1809.27
3	Thovalai	4289.01
4	Kurunthencode	1230.89
5	Kozhiporvilai	183.79
6	Melpuram	1.85
7	Killiyoor	0.08
8	Munchirai	12.345
	Total	11224.14

In Kanyakumari district paddy is grown in all the blocks. From among the eight blocks four blocks with maximum area under rice cultivation were selected and proportionate random sampling method was used for selection of respondents. The blocks identified were Thovalai, Rajakamangalam, Agastheeswaram and Kurunthancodu blocks. From these blocks farmers has been identified with proportionate sampling method.

Sampling Design

A total of 128 paddy farmers were selected by proportionate random sampling. A well-structured interview schedule was used for collecting data. Potential yield, actual yield obtained were recorded. Suitable statistical tools were utilized for analysis.

Data collection

The study was based upon both primary and secondary data gathered during the course of investigation.

Data collection Tool

A pretested interview schedule was used for collecting the required data from the sample farmers

Results and discussion

Though the production level of rice has increased, there still exists a gap between what is achieved and what actually could be achieved in farmers' fields through interventions. It is therefore needed that an attempt is made to analyse the magnitude of the gaps in attainable yields and to explore the possibilities of relaxing existing constraints in order to reduce the yield gaps and to assess the efficiency levels of farmers resource use.

Table 2: Indices of yield gap of rice in Kanyakumari district (per cent)

Yield gap of district (Kg/ac)	Index of realised potential yield (%)	Index of realised potential farm yield (%)	Index of yield gap (%)
1135	68.3	99.8	31.7

Yield gap of Rice cultivation in the district was 1135 ka/ac which is the sum of YG I and YG II. The indices of yield gap of rice cultivation are given through Table 2. In the case of paddy, The Index of Realised Potential Yield (IRPY) of farmers was found to be 68.3% which means that the actual yield achieved by farmers is only 68.3% of the maximum potential yield and that there is untapped potential of 31.7 per cent of yield for rice in the district which we need to enhance through improved production technologies like increasing germination percentage with technologies like TNAU vidhai amiratham, reducing sterility using crop booters like Rice bloom which can increase yield by 15-20% and stage specific management practices in INM and IPDM. There is more scope for increasing 31.7% of additional yield by adopting improved production technologies.

Index of realised potential farm yield IRPFY at farm level was (99.8%) which means the actual yield is nearly identical to the theoretical maximum potential yield with farm conditions in the particular area.

Table 3: Yield gap of rice cultivation in major rice growing blocks

Block	Area (Ha)	Yield gap	Index of realised potential yield (IRPY) (%)	Index of yield gap (%)
Agastheeswaram	3696.9	1197.9	67.7	32.3
Thovalai	4289.01	1096.8	69.3	30.7
Rajakkamangalam	1809.27	1198.7	66.4	33.6
Kurunthancodu	1230.89	1261.5	64.6	35.4

Maximum yield gap was observed in Agastheeswaram block with Yield gap Index 32.3%. the major rice growing tract was thovalai block with YGI 30.7 and Index of Realised Potential Yield (IRPY) of Thovalai was 69.3%. this indicates that the actual yield achieved by farmers in Thovalai is only 69.3% of the maximum potential yield and that there is untapped potential of 30.7 per cent of yield for rice in the district.

Yield Gap Analysis of Paddy variants

The Paddy variants grown in the district were ASD 16, TPS 5, ASD 21, Samba, ADT 59, TPS 3 and CR1009 sub 1 grown in 11224.14 ha. It had been observed that the yield gap index was highest in ASD 16 with 46.97 percent. Yield gap index for other major variants are TPS 5 - 31.84 percent and ASD 21- 31.03 percent. The factor responsible for higher yield gap Index in ASD 16 variety was due to its lodging feature during harvest and both lodging and sprouting in ASD 21. In TPS 5 it is the varied topography and traditional agronomic practices followed by farmers.

Table 4: Yield Gap Index of Paddy Variants of Kanyakumari district

Variants	Potential Yield	Yield Gap	YGI (%)
ASD 16	2436	1634.5	46.97
TPS 5	3035	1257.8	31.84
ASD 21	3480	1080	31.03
Samba	1827	527.17	18.3
CR 1009 Sub 1	2175	285	8.96
ADT 59	2341	257.5	11.0
TPS3	2610	238.25	10.01

In other varieties the area grown was lesser and potential yield was low. There is vast scope for increasing the

potential yield by improved production technologies in these major ruling varieties which has recorded higher yield. A stable high potential yield was observed in TPS 5 variety.

The Technological index (TI) of TPS 5 rice cultivation was found to be 2.44% which is a very low "technology gap". This implies better performance of the variety in the field and this variety is more suitable to the climatic condition and crop management practices of the farmers. The performance of TPS 5 variety indicates that it is best suited for the climatic conditions in the district and can be upscaled

The demonstration yield of rice TPS 5 in the district was 3480 kg/ac and average yield was 2408kg/ac. An Extension Gap of (1072kg/ ac) was 2.68 t/ha which means that this variety yielded 2.68 t/ha higher than the average yield obtained by farmers.

Yield Gap index (YGI) of TPS 5 variety was 31.84% which means that there was more scope for achieving untapped potential yield through improved production technologies to obtain an additional yield of 772kg/ac. (1.9t/ha).

Factors influencing yield gap in rice cultivation

Socio-economic factors are crucial for limiting access to technology, farmers' income levels, and credit availability that impact farmers' ability to implement improved technologies. Analysis was done for finding out the relationship between the factors that impact yield gap and the results are presented below.

Multiple linear regression

The backward stepwise method is used to produce an initial screening of the predictors. The multiple linear regression analysis shows that Experience and Annual income are significant @0.05% level of significance

Table 5: Correlation matrix (Pearson)

	YGI	Age (X1)	Education (X2)	Experience (X3)	Area under Cultivation (X4)	Own land (X5)	Annual income (X6)
YGI	1	0.02984	-0.184368	-0.087436	-0.0156996	-0.228516	-0.977681
Age (X1)	0.02984	1	0.224024	-0.644549	0.0150906	-0.008210	-0.006682
Education (X2)	-0.184368	0.224024	1	-0.120769	-0.0252282	0.0674051	0.200845
Experience (X3)	-0.087436	-0.644549	-0.120769	1	0.116633	0.214063	0.101898
Area under cultivation (X4)	-0.01567	0.0150906	-0.025228	0.116633	1	0.615917	0.0254568
Own land (X5)	-0.228516	-0.0082101	0.0674051	0.214063	0.615917	1	0.217588
Annual income (X6)	-0.977681	-0.0066816	0.200845	0.101898	0.0254568	0.217588	1

Results of the multiple linear regression indicated that there was a very strong collective significant effect between the X1, X2, X3, X4, X5, X6, and Y, ($F(1, 98) = 2122.21, p < .001, R^2 = 0.96, R^2_{adj} = 0.96$).

$$\hat{Y} = 93.051008 - 12.418058 X_6$$

This can be interpreted that every unit increase in X6

(Annual Income) limits the yield gap. This means that increase in annual income reduces yield gap index.

Annual income has impacted yield gap index of individuals. Similarly for increase in experience there is decrease in yield gap index. The analysis interprets that for higher socio-economic status combined with age and experience has reduced yield gap in rice.

Factors responsible for yield gap indicated by farmers are

Labour scarcity and high labour charges (98%) was a major factor during peak seasons that limits farm operations of farmers majority of whom are small and marginal farmers, resulting in low yield. The next limiting factor is the coincidence of rain during harvesting season and due to lesser no. of harvesting machines which delays harvests

resulting in either sprouting or post-harvest losses (60%). Other issues faced by farmers are puddled field conditions preventing mechanized farm operations (31%) opting for manual operations that increases cost of cultivation, in direct seeded rice wild rice competition is a major challenge (20%) which causes extensive loss and traditional farming practices (17%) due to marginal holdings.

Table 6: Topography based problems faced in paddy cultivation

Block	Villages	Topography based problem
Thovalai (south)	Thirupathisaram and Thazhakudy	Puddled wetland preventing mechanisation
Thovalai (north)	Derisanamcope, Thellanthi, Bhoothapandy	Submergence of fields during floods from Pazhayar
Thovalai(west)	Sembagaramanputhoor	Late release of water from reservoir during critical stages
Agastheeswaram	Puthalam, Ramapuram	Region lies in the tail end of Thovalai channel Command Area and irrigation water scarcity during peak season
Kurunthancodu	Palattinkarai, Poovadi, Manavalakurichi	Tradition farming practices

Topography based issues as mentioned in table 5 can be rectified through agronomic practices using improved production technologies like increasing germination percentage with TNAU Vidhai Amirtham, reducing sterility with TNAU Rice Bloom which can increase yield by 15-20%, stage specific biofertilizers and management practices

in INM and IPDM.

The reasons for the areas that can be concentrated for obtaining potential yield at farm level were identified through the perception by farmers and presented in the table 6 below.

Table 6: Garrett's ranking technique for perception by farmers for

S. No	Perception by farmers for potential yield at farm level	No	Rank
1	Timely harvest	94	I
2	Improved seed varieties	92	II
3	Irrigation during critical phases	88	III
4	Transplanting rather than direct sowing in I season	87	IV
5	Varieties suitable to climate and season	84	V
6	Crop recommended spacing	74	VI
7	Foliar application of crop boosters	66	VII
8	Use of bio fertilizers- seed treatment, seedling treatment	62	VIII
9	Farm mechanisation to reduce loss of spillover of grains	51	IX
10	Timely availability of critical inputs	44	X

Timely harvest is a major issue in the area due to availability of machines or labours during harvest time. Also, many times harvesting time coincides with rain which further adds to the crisis. Development of new rice cultivars that are adaptable to the climatic conditions of the district is imperative, as climate variability poses a substantial threat to global rice production. It has been noted that farmers with a better socio-economic status had accessibility to resources that had reflected in reduction in yield gap. Moreover, providing smallholder farmers with access to information, critical inputs and capacity-building initiatives for biofertilizers and crop boosters with adequate follow-up can enhance their adaptive capacity and reduce socioeconomic vulnerability.

Conclusion

Identifying the Technological index that indicates the feasibility of new technology is very important for transfer of any technology among farmers. Indicators of yield gap are technological index, extension gap and yield gap index. This study has extensively brought up the levels of these indicators which has identified the impact KVK has created in promoting rice production technologies in the district. But still Timely harvest, Development of new rice cultivars with access to information, critical inputs and capacity-building initiatives can enhance the adaptive capacity of small and

marginal farmers and reduce their socioeconomic vulnerability to yield gap. Efforts need to be made towards achieving the untapped potential to attain maximum potential yield in Paddy cultivation through improved production technologies. Transplanting can be recommended to prevent yield loss due to direct seeded rice cultivation and suitable package of practice can be suggested for slushy field or swampy/marshy wetland conditions. ASD 16 with highest yield gap and has to be replaced with new varieties. TPS 5 variety with Technological index (TI) and Extension gap can be upscaled to flood prone areas due to its non-lodging feature.

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