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Factors influencing yield gap of rice varieties in the districts of South Kerala

Shanila S

Ph.D. Scholar, Department of Agricultural Extension, College of Agriculture, Kerala Agricultural University, Vellanikkara, Thrissur, Kerala, India

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Corresponding Author: Shanila S

Abstract

The present study was undertaken during the year 2020-2021 in Thiruvananthapuram, Kollam, Alappuzha, Pathanamthitta, Kottayam, Ernakulam and Idukki districts representing the rice growing tract of South Kerala. The study was done to determine the extent of yield gap in rice production and assessment of the factors influencing yield gap of rice varieties. Total of 105 rice-growing farmers were selected for the research. The analysis of respondent rice farmers based on their yield gap in rice production revealed that Jyothi rice variety had a higher yield gap index of 28.91 percent followed by 27.09 percent in Kanchana, 24.35 percent in Hraswa, 21.83 percent in Uma and 20.53 percent in Manurathna and it can be deduced from the Friedmann test results that socio-economic factors and institutional factors were the most important components affecting the yield gap of Uma rice variety whereas, biophysical and climatic factors were the most key factors influencing the Jyothi rice variety's yield gap. Thus, the higher yield gap in Jyothi can be significantly reduced by improving the biophysical and climatic factors corresponding to the farmers.

Keywords: Yield gap, rice varieties, farmers, technology adoption, south Kerala, climatic factors

Introduction

Rice is the most widely produced cereal crop in the world. Thousands of millions of people's culture, traditions, nourishment, and economics have all been influenced by it. Rice provides calories and protein to more than half of the world's population, especially in developing countries. To meet the rising demand, the world will need around 760 million tonnes of rice by the year 2025, which is 35 percent greater than the rice production in 1996 (Duwayri *et al*., 1999) [1]. Considering its importance, the United Nations designated year 2004 as the "International Year of rice".

India occupies first place in area and second place in the production of rice in the world, accounting for some 20 percent of global production. It is also one of the largest consumers of the grain, with more than half of India's 1.3 billion people relying on rice for survival. Rice production of India increased from 64.6 million tonnes in 1971 to 178 million tonnes in 2020 growing at an average annual rate of 2.68 percent (WDA, 2021) [7].

According to the International Rice Research Institute, the sustainability of rice farming in India is specifically threatened by so many difficulties including the yield gap problems. As a result, it was proposed that efforts be made in research and extension to break the trend of stagnant yield and close yield gaps to improve rice production and ensure world food security (IRRI, 2013) [4]. The gaps between research yields and actual farmers' yields in a specific location and season are more accurate indicators of yield gap. Yield gap I and Yield gap II are the two main components of yield gap. Yield Gap I is the difference between research station yield and potential farm yield obtained from demonstration plots, whereas Yield Gap II is the difference between yield obtained from the nearest demonstration plot and actual yield obtained from farmers' fields. Yield Gap I cannot be narrowed or exploited because of elements that are generally not transferrable, such as environmental conditions and some built-in component technologies present at research stations. Yield Gap II, on the other hand, is primarily due to differences in management techniques and it arises because farmers adopt sub-optimal input doses and cultural practices. As a result, Yield Gap II is controllable and can be decreased by increasing research and extension efforts (Lobell *et al*., 2009) [5].

In Kerala, the rice output has been reduced due to high farming costs, shortage of excellent quality seed, disease outbreaks, land fragmentation and poor marketing effectiveness. Consequently, farmers are abandoning rice farming in favour of cash crops such as plantation crops, vegetables, and fruits. Significant research and development are required to maintain current levels of food grain production without causing any damage to natural resources. Analysis of the yield gap in rice production is crucial under these circumstances. Thereby, the present study will help to identify the extent of yield gap among the rice farming community of South Kerala, as well as evaluating the factors influencing this yield gap. In this context, the current study was conducted in the rice-growing tracts of South Kerala, including Thiruvananthapuram, Kollam, Alappuzha, Pathanamthitta, Kottayam, Ernakulam, and Idukki districts with the following objectives:

To measure the extent of yield gap of rice varieties released

by Kerala Agricultural University (KAU) and the factors contributing it among the rice farmers of South Kerala.

Materials and Methods

Kerala is a state in India with a long history and culture of rice farming and rice farming is seen as a symbol of affluence and traditional heritage. Kerala State is divided into 14 districts *viz*., Alappuzha, Ernakulam, Idukki, Kollam, Pathanamthitta, Thiruvananthapuram and Kottayam (constituting South Kerala) and Kannur, Kasargode, Kozhikode, Palakkad, Malappuram, Thrissur and Wayanad (constituting North Kerala), of these Alappuzha and Palakkad had the largest rice-growing area. This study looked at the cultivation of local and KAU-released rice varieties in the main rice-growing regions of South Kerala. Of all the 7 districts comprising Southern part of Kerala, a list of 7 blocks namely; Veliyanad, Alangad, Nedumkandam, Sasthamcotta, Ettumanoor, Pulikeezhu and Kilimanoor were purposively selected from each district with the help of scientists from Krishi Vigyan Kendras (KVKs), Regional Agricultural Research Stations (RARS) and Agricultural officers from respective Krishi Bhavans, based on highest area under paddy cultivation. Subsequently, one panchayat with maximum rice farmers from each block were selected in consultation with the PAO, namely Ramankary, Karumalloor, Udumbanchola, Sooranad North, Thiruvarppu, Peringara and Nagaroor panchayats. Following the discussions with the corresponding agricultural officers, a list of rice farmers from designated panchayats were obtained. By adopting a simple random sample technique, fifteen rice farmers from each panchayat were chosen, totalling 105 respondents. The criteria for selecting the farmers were that they should have a minimum of 50 cents of rice field. The information was collected by personal interview method. The average yield gap of popularly cultivating KAU released rice varieties of respondent rice farmers for the first cropping season was studied using the following equation of yield gap index and factors influencing yield gap of rice varieties was examined using the friedman test.

Yield Gap

Yield gap is operationally defined as the difference between the maximum potential yield obtained at the research station and farmer's actual yield. It was hypothesized as caused by biophysical and socio-economic constraints. Biophysical constraints include the uncontrollable natural factors like rainfall, soil fertility, pests and diseases. Socioeconomic constraints include the social and economic conditions that prevent farmers from using the recommended social technology.

Accordingly, the following index was used to calculate the variable as given below.

$$\text{Yield gap index (\%)} = \frac{\text{Potential yield} - \text{Actual yield}}{\text{Actual yield}} \times 100$$

The maximum attainable yield in the given environments as determined for eg: by simulation models with plausible physiological & agronomic conditions (Evans and Fischer, 1999) [2]

Actual yield

It is actually the farm yield which reflects the current soil, climate conditions and farmer management levels (Sadras *et al*., 2015) [6]

Yield gap

Yield gaps are estimated by the difference between potential yield and average farmers' yields over some specified spatial and temporal scale of interest (Lobell *et al*., 2009) [5]

Friedman Test

When the dependent variable being measured is ordinal, the non-parametric test called Friedman test is used, to examine the differences between groups. Each row (or block) is ranked collectively, and the values of these ranks are then considered by columns. This tool was adapted here to study the factors contributing to the yield gap in paddy and its influence.

Results and Discussion

The average yield gap of popularly cultivating KAU released rice varieties of respondent rice farmers for the first cropping season was studied and the results are presented.

Table 1: Average Yield gap and Yield Gap Index of KAU rice varieties by farmers in South Kerala

Rice Varieties	No. of farmers	Research Station yield (q/ac)	Average yield obtained by the rice growers (q/ac)	Yield Gap Average (q/ac)	Yield Gap Index (YGI)
1. Uma	86	32	25.01	6.988	21.838
2. Jyothi	21	28	19.90	8.095	28.91
3. Manurathna	8	28	22.25	5.75	20.53
4. Kanchana	6	32	23.33	8.67	27.09
5. Hraswa	5	23	17.4	5.6	24.35

The result in Table 1 showed that, 32 q/ac is the potential yield of Uma variety and recorded 25.01 q/ac as the average yield of 86 rice farmers surveyed from all the seven districts except Idukki, with a mean yield gap of 6.988 q/ac and yield gap index of 21.838 percent. The yield gap index of Uma by the respondent farmers ranged from 0 to 43.75, as shown in Fig.1. As can be seen from the boxplot, the maximum yield gap index value of Uma is 43.75 percent, while the minimum yield gap index value is 0 percent. About 12.50 percent farmers had low yield gap index, that is, they fall in the lower quartile range (Q_1), 21.87 percent falls in the middle quartile region (Median/ Q_2), while 25.00 percent of respondents had high yield gap index and they fall in the upper quartile region (Q_3). The distribution of respondents

based on yield gap index of Uma followed a negatively skewed distribution since the median (21.87%) is closer to the upper or Q_3 quartile (25.00%) which means the data constitute higher frequency of low valued scores.

The result in Table 1 showed that, 28 q/ac is the potential yield of Jyothi variety and recorded 19.90 q/ac as the average yield of 21 rice farmers surveyed from all the seven districts with a mean yield gap of 8.095 q/ac and yield gap index of 28.91 percent. The yield gap index of Jyothi by the respondent farmers ranged from 10.71 to 53.57, as shown in Fig.2. As can be seen from the box plot, the maximum yield gap index value of Jyothi is 53.57 percent, while the minimum yield gap index value is 10.71 percent. About 14.29 percent farmers had low yield gap index, that is, they fall in the lower quartile range (Q_1), 17.86 percent falls in the middle quartile region (Median/ Q_2), while 42.86 percent of respondents had high yield gap index and they fall in the upper quartile region (Q_3). The distribution of respondents based on yield gap index of Jyothi followed a positively skewed distribution since the median (17.86%) is closer to the lower or Q_1 quartile (14.29%) which means the data constitute higher frequency of high valued scores.

The result in Table 1 showed that, 28 q/ac is the potential yield of Manurathna variety and recorded 22.25 q/ac as the average yield of 8 rice farmers surveyed from Idukki district with a mean yield gap of 5.75 q/ac and yield gap index of 20.53 percent. Generally, the yield gap in case of Manurathna variety is less compared to others, but here it shows a large yield gap of 20.53 percent due to a smaller number of farmers cultivating this variety, which is assessed mostly in Idukki district. Also from the results we can see, 32 q/ac is the potential yield of Kanchana variety and recorded 23.33 q/ac as the average yield of only 6 rice farmers surveyed from Ernakulam district with a mean yield gap & yield gap index of 8.67 q/ac, 27.09 percent respectively and 23 q/ac is the potential yield of Hraswa variety and recorded 17.40 q/ac as the average yield of only 5 rice farmers surveyed from Idukki district with a mean yield gap of 5.6 q/ac and yield gap index of 24.35 percent.

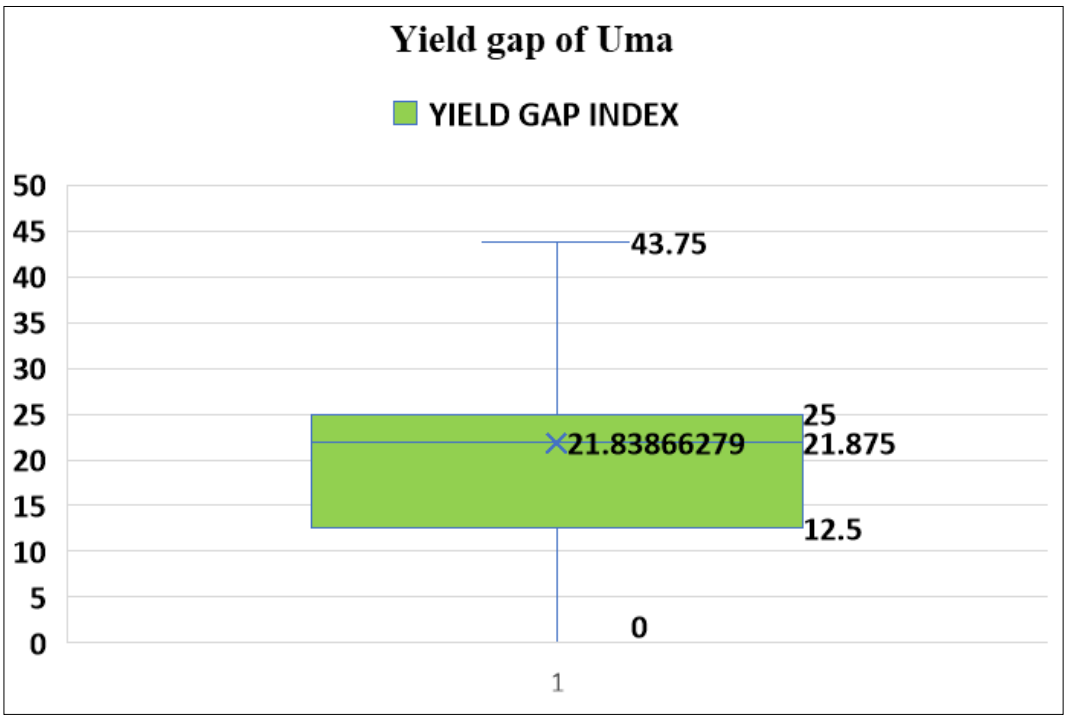

Fig 1: Distribution of respondents based on yield gap of Uma (Box Plot)

Sample size (n)	86
Minimum	0
Q1	12.5
Median	21.875
Q3	25
Maximum	43.75
Mean	21.838

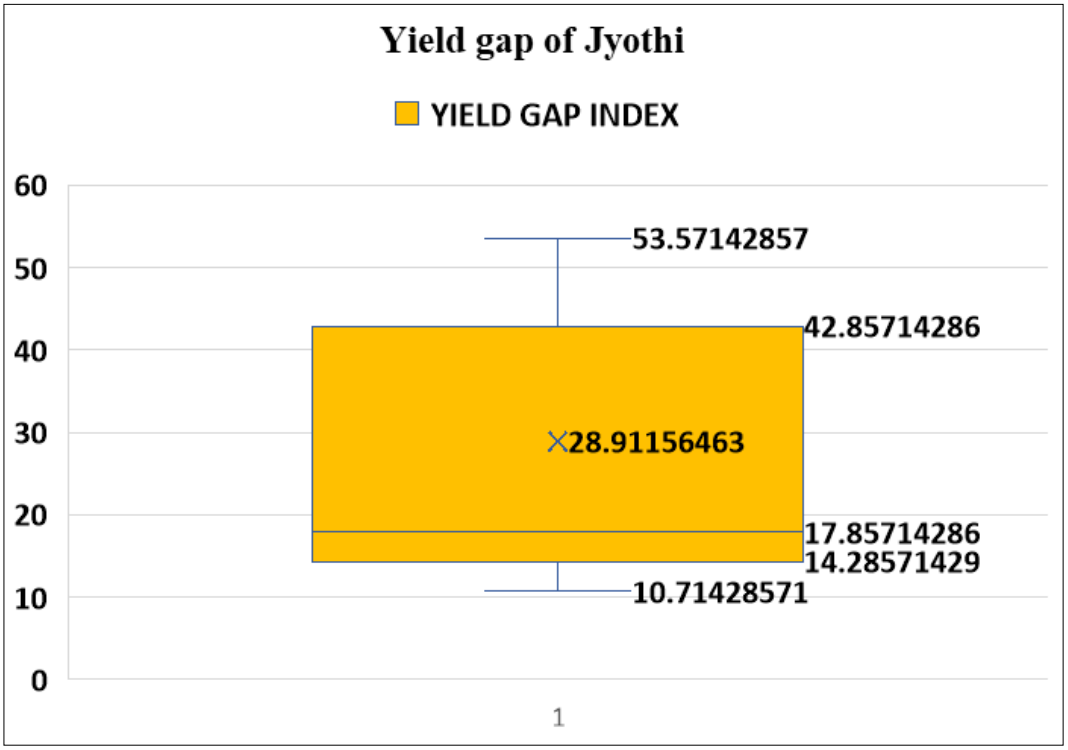

Fig 2: Distribution of respondents based on yield gap of Jyothi (Box Plot)

Sample size (n)	21
Minimum	10.71
Q1	14.29
Median	17.86
Q3	42.86
Maximum	53.57
Mean	28.91

Assessment of the factors influencing yield gap of rice varieties

A total of 5 factors were analysed, all of which were seen by farmers as contributing to the rice yield gap and the influence of these factors on the rice yield gap was examined using the Friedman Test and the results are presented in Table 2 & 3.

Friedman test for factors affecting yield gap in Uma rice variety

H0: There is no significant difference between the factors affecting yield gap of Uma variety

H1: There is significant difference between the factors affecting yield gap of Uma variety

Table 2: Friedmann test for analysing the factors affecting yield gap in Uma

Factors affecting yield gap	Mean sum
Biophysical factors	2.51
Climatic factors	2.54
Socio- economic factors	3.91
Institutional factors	3.89
Factors related to technology transfer	2.15

Sample size (n):	86
Degrees of freedom	4
Observed value ($\chi 2$)	161.09
Critical value	9.49
Asymp. Sig	<0.001
α	0.05

It could be seen from Table 2 that socio-economic factors (family size, education level of farmers, communication gap with extension agents, social and economic status of farmers) and institutional factors (Government policies, rice price, agricultural credit, input price, input supply & land tenure) were the most important components affecting the

yield gap of Uma rice variety with a mean sum of 3.91 and 3.89 respectively. Here we reject the null hypothesis because the results of the Friedmann test revealed that the chi square value is greater than the critical value, indicating there is significant difference between the factors affecting yield gap of Uma variety. Thus, the yield gap in Uma can be considerably reduced by improving the socio-economic and institutional factors corresponding to the farmers.

Friedman test for factors affecting yield gap in Jyothi rice variety

H0: There is no significant difference between the factors affecting yield gap of Jyothi variety

H1: There is significant difference between the factors affecting yield gap of Jyothi variety

Table 3: Friedmann test for analysing the factors affecting yield gap in Jyothi

Factors affecting yield gap	Mean sum
Biophysical factors	3.79
Climatic factors	3.57
Socio- economic factors	3.50
Institutional factors	2.52
Factors related to technology transfer	1.62

Sample size (n):	21
Degrees of freedom	4
Observed value ($\chi 2$)	46.96
Critical value	9.49
Asymp. Sig	<0.001
α	0.05

It could be seen from Table 3 that biophysical factors (soil fertility, post-harvest losses, seed shattering of variety, improper management practices) and climatic factors (flood, drought, salinity, poor irrigation facilities) were the most important components affecting the yield gap of Jyothi rice variety with a mean sum of 3.79 and 3.57 respectively. Here we reject the null hypothesis because the results of the Friedmann test revealed that the chi square value is greater than the critical value, indicating there is significant difference between the factors affecting yield gap of Jyothi variety. As it is more prone to seed shattering, which results in large yield losses, explaining why it has a much wider yield gap than other varieties. Thus, the yield gap in Jyothi can be significantly reduced by improving the biophysical factors affecting farmers.

Conclusion

In Kerala, paddy fields occupy 7.46 percent of the total cropped area of the state. The land has witnessed a steady decline in the area of rice fields since 1970s and they are constantly getting converted for other purposes. In the last four decades from 8.82 lakh hectare, the paddy area has come down to 0.58 lakh hectare and the production has also declined accordingly from 13.76 lakh MT in 1972-73 to 1.82 lakh MT in 2020-21 (GoK, 2021). Therefore, analysis of yield gap in rice production is crucial under these circumstances.

An inquiry in to the yield gap of KAU released rice varieties among the farmers revealed that Jyothi rice variety had a higher yield gap index of 28.91 percent. Hence, an extension focus must be given for making available location specific agricultural inputs and management strategies to bridge the yield gap. Also, from the friedmann test results, it was deduced that socio-economic factors and institutional factors were the most important components affecting the yield gap of Uma rice variety whereas, biophysical and climatic factors were the most key factors influencing the Jyothi rice variety's yield gap.

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