DEPARTMENT OF AGRICULTURAL ECONOMICS,
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Title of Thesis	**:**	An economic analysis of yield gap in rice in Raigad district (M.S.)
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THESIS ABSTRACT

The present study entitled 'An economic analysis of yield gap in rice in Raigad district (M.S.) was undertaken with specific objectives *viz.*, to estimate the input gaps and yield gap in rice, to identify the factors responsible for yield gap, to estimate their contribution in yield gap, to study the economic comparison between the potential farm yield and actual yield and to identitify the constraints responsible for yield gap in rice.

A sample of sixty rice growers from Karjat and Roha tahsils of Raigad district was divided into three groups on the basis of their operational holding as small (below 1 ha), medium (1 - 3 ha) and large (above 3 ha).

It was observed that the levels of input used on demonstration farms were higher as compared to that at farmers' level with respect to all production inputs except that of seedrate. There were much higher gaps in the use of plant nutrients like P and K which was found to be major factors responsible for yield gap in rice.

The results of the study indicated that yield gap-I was quite narrow (2.11 q/ha) in comparison to yield gap-II which was estimated to be 13.28 quintals per hectare (19.80%) at an overall level. Thus, the total yield gap overall farm level came to 15.39 quintals per hectare. Relatively smaller

size of yield gap-II was observed on medium farms (12.73 q/ha) as compared to small (13.48 q/ha) and large (13.31) farms.

The functional analysis of yield gap in rice revealed that the gap between the recommended levels of all key inputs at demonstration farms and actual input use levels was found to be a major reason for yield gap in rice.

The decomposition analysis indicated that suboptimal use of inputs on the sample farms contributed about 31.95 per cent to yield gap in rice at an overall level. It was about 37.13 per cent, 34.59 per cent, 32.73 per cent on small, medium and large farms, respectively.

It was found that demonstration farms obtained higher returns over working expenses (7486.01) than that obtained at overall farms (Rs. 2184.89). Small farms were found to obtained lower returns over working expenses as compared to medium and large farms. The major constraints perceived by the farmers were abnormal distribution of rainfall, high cost of fertilizers, costly pesticides, shortage of funds and non-availability of critical inputs like seed, fertilizers and pesticides in time. Therefore, it was suggested to take up the extension education activities in order to enhance the rice productivity on actual farms.

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(Priya Vijay Jadhav)

Appendix II

Geometric mean levels of inputs used and output obtained on the demonstration farms and sample farms

Sr. No.	Variables	Demonstration on farms	Actual farms			
			Small	Medium	Large	Overall
1.	Human labour (days)	186.40	183.38	154.39	160.57	170.10
2.	Bullock and machine (Rs.)	3074.93	2917.51	2868.79	2643.53	2839.87
3.	Seedrate (kg)	44.56	59.83	55.19	63.89	59.19
4.	Manures (Rs.)	2108.83	1325.29	1349.76	1801.33	1424.03
5.	Expenditure on Nitrogenous fertilizers (Rs.)	949.15	921.26	909.11	802.77	893.79
6.	Expenditure on phosphoric fertilizers (Rs.)	772.99	317.91	333.81	334.98	323.03
7.	Expenditure on potassic fertilizers (Rs.)	266.93	109.28	165.89	130.15	127.61
8.	Yield (qtls)	44.46	30.80	31.27	30.96	30.97

Appendix I

Production function estimates in rice production at farmers' level and on demonstration farms

(Per hectare)

Sr. No.	Variables	Demonst-ration on farms	Actual farms			
			Small	Medium	Large	Overall
1.	Constant	-3.4783	-4.3781	-0.8043	-4.089	-3.1559
2.	Human labour (days)	0.0619*** (0.0167)	0.0019 (0.0071)	1.6983*** (0.2566)	0.0007 (0.0008)	0.0100** (0.0049)
3.	Expenditure on bullock and machine power (Rs.)	0.4134*** (0.1319)	0.9042*** (0.0463)	-0.6771** (0.2576)	0.7641*** (0.0659)	-0.0017 (0.0039)
4.	Seed rate (kg)	-0.0026 (0.0021)	-0.033 (0.0006)	0.1388 (0.1242)	0.0022 (0.0002)	-0.0005 (0.0008)
5.	Expenditure on manure (Rs.)	0.2482** (0.0899)	0.0687* (0.0412)	0.0345 (0.022)	0.0992** (0.0465)	0.6237*** (0.0439)
6.	Expenditure on N fertilizers (Rs.)	0.0124 (0.0145)	-0.0334*** (0.0106)	0.0865 (0.071)	0.1069* (0.0593)	0.3644 (0.0860)
7.	Expenditure on P fertilizer (Rs.)	0.1911* (0.0861)	0.0266 (0.0191)	0.0177 (0.0623)	0.0060 (0.0119)	- 0.5613*** (0.0160)
8.	Expenditure on K fertilizer (Rs.)	0.0699** (0.0326)	0.0299*** (0.0087)	-0.0529 (0.0458)	0.0208 (0.0148)	0.5570*** (0.0263)
	R^2	0.98**	0.96**	0.74**	0.97**	0.98**

***Significant at 1 per cent probability level

** Significant at 5 per cent probability level

*Significant at 10 per cent probability level.

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) commended recognition as a supreme commodity to mankind, because rice is truly life, culture, a tradition and a means of livelihood to millions of people all over the world. It is not only a cereal crop but also a way of life in Asian countries. It contributes about 40 to 70 per cent of the population's total calorie intake. Hence, sustained production and increased productivity of rice crop is critical for food and nutritional security in Asia (Anonymous, 1997).

As per the estimates of International Rice Research Institute (IRRI), rice was cultivated on an area of about 148 million hectares in the world with total production of around 591 million tonnes during the year 2003-2004. Asian countries occupy an important position in rice production. Nearly 91 per cent of the total rice is produced in Asian countries. China and India are the major rice producing countries in the world together contributing 55 per cent of the world rice production (www.irri.org.)

In India, rice is the only promising crop to acquire self-sufficiency in foodgrain production for the increasing population. Rice crop occupies the largest cultivated land in the country. It was cultivated on an area of 42.40 million ha with the production of 88.28 million tonnes in the year 2003-04 (www.fas.usda.gov). Technology break-through in the field of agriculture has resulted in the spectacular performance in rice production in the country, but with regards to average productivity, such a phenomenon was not forthcoming. As compared to other Asian countries, the production of rice per unit of land (productivity) is very low in India. In the year 2003-04, India had average 2.08 tonnes per hectare yield of rice only as compared to 4.24 tonnes in China, 4.36 tonnes in Korea Republic, 4.24 tonnes in Japan and 2.94 tonnes in Indonesia. The main reason of low productivity of rice in India is regional disparities in rice productivity due to diverse soil and climatic conditions.

In the year 2002-2003, in India, the area under rice crop was maximum (5.84 million ha) in Uttar Pradesh followed by West Bengal (5.44 million ha) and Andhra Pradesh (4.03 million ha). In terms of production of rice, West Bengal ranked first with 12.43 million tonnes followed by Uttar Pradesh (11.54 million tonnes) and Andhra Pradesh (11.45 million tonnes). As regards to productivity, Punjab ranked first with 3.51 tonnes followed by Tamil Nadu with 3.42 tonnes and Andhra Pradesh with 2.84 tonnes (www.janmanch.org).

It is often reported that the actual yield realized on the farmers' fields in India are lower than those obtained in the research farms as well as on the demonstration plots. Even in the areas, where the adoption of modern varieties is relatively high, farmers' rice yields are often lower than the research station's yield. This difference between the research station's yield and actual yield was referred to as 'yield gap' while the factors preventing farmers from achieving the full potential of the new improved technology were referred to as 'yield constraints'. These factors may be agronomical, institutional, economic or social (Gomez, 1977).

The green revolution has enabled rice production to meet the demands of the growing population. Since, 1990, however, rice production has increased at a lower rate than the population growth rate. This deceleration in the growth of rice production is a cause of concern in terms of world food security. It has been the topic of numerous reviews and several rice scientists have alerted those concerned of the risk of a pending food crisis. In 1998, the average rice yields in 81 countries were less than the world average yield of 3.8 tonnes per hectare, indicating the existence of yield gaps. Also the progressive farmers usually obtain higher yields and more profit than ordinary farmers, indicating the presence of knowledge gaps. The yield gap in rainfed rice is usually larger than in irrigated rice. This fact suggests the potential for increasing rice production (Trans, 1999).

There is a general notion that the farmers are not fully employing the available crop production technology which led to yield gap. In this context, there is a need to study the magnitude of yield gap in rice and identify the constraints resulting in yield gap. Once the constraints operating in the area are discovered, attempts could be made to narrow down the yield gap between potential and actual yield.

1.1 Selection of study area

Rice is the second largest important food crop next to jowar in Maharashtra. It was cultivated on an area of about 15.23 lakh hectares with total production of 18.54 lakh tonnes in the year 2002-2003 in the state. Konkan region accounts for 28.31 per cent of total area in the state while it contributes about 40.93 per cent of the state's rice production (www.agri.mah.nic.in).

Among the four districts of Konkan region, Raigad is the major rice producing district which accounts for 8.74 per cent area and 18.24 per cent production of rice in Konkan region. According to 2002-2003 estimates, in Raigad district, rice occupied about 1.25 lakh hectares areas with the production of 2.56 million tonnes in *Kharif* season. The average productivity was 2.06 tonnes per hectare. Eventhough the average productivity of *Kharif* rice was higher in the district as compared to that in Konkan which was 1.73 tonnes per hectare, a need was felt to carry out the yield gap analysis in *Kharif* rice as the scope for increasing crop production can only be achieved through increased productivity. Therefore the study entitled, "An economic analysis of yield gap in rice in Raigad district" was undertaken with following specific objectives.

Objectives :

1) To estimate the input gap and productivity gap in rice.
2) To identify the factors responsible for yield gap and to estimate their contribution in yield gap.
3) To study the economic comparison between potential farm yield and actual farm yield.
4) To identify the constraints responsible for yield gap.

1.2 Scope and utility

The findings of the study will be helpful to rice growers in Raigad district in overcoming the bottlenecks which hinder the adoption process of available technology. This knowledge could be gainfully utilized to serve as a feedback to future research to improve or modify the technology to suit the farmers with different resource base. It will be also useful to improve the technical data base of extension workers and also for policy makers to suggest the necessary modifications in the farmers' environment and management practices.

1.3 Limitations of the study

The present study is restricted to two tahsils of Raigad district. So also, the conclusions drawn from the study will strictly depend on the honesty and ability of the respondents to recollect the information. However, the findings of the study will be applicable to similar agroclimatic conditions for rice production.

CHAPTER II

REVIEW OF LITERATURE

An idea of the findings of the earlier studies and methodology adopted therein assumes a great importance for the investigator with regards to evaluate the objectives of the study. It also provides orientation about the topic of investigation and about the subject as a whole. The studies having relevance to the objectives of the present study have been reviewed and grouped into following heads :

2.1 Yield gap analysis

2.2 Factors contributing to yield gap

2.3 Economic comparison of farmers' yield with potential and potential farm yield

2.4 Constraints in yield gap

2.1 Yield gap analysis

International Rice Research Institute (IRRI) has developed the methodology to identify the factors affecting yield gap and estimate their contribution to yield gap in rice crop (Gomez, 1977 and Herdt, 1980). As per that methodology, total yield gap was divided into two components – Gap I corresponding to the difference between the research station yield (potential yield) and the demonstration plot's yield (potential farm yield) and Gap II representing the difference between the potential farm yield and actual farmers' yield. According to them, Gap I and II were caused by uncontrolled environmental conditions and various socio-economic and biological factors operating at the farm level, respectively. Eventhough the main focus of IRRI was on Gap II and total yield gap was worked out as the difference between the potential yield and actual farm yield. This methodology was extensively used in several studies, in the past.

Kalirajan (1980), in a study which conducted on the contribution of location specific research to agricultural productivity in the most progressive village in Gobi-chettipalayam block in Tamil Nadu, observed that the yield from location specific modern varieties of rice (ADT 31 and CO 37) was 26.8 quintals per acre, whereas the yield obtained from exotic modern variety (IR 20) under field conditions was 17.7 quintals per acre, thus showing a gap of 9.1 quintals per acre between the two varieties.

Rangaswamy (1982) studied the constraints in adopting an improved technology for coarse grains. He observed that the yield of jowar crop on demonstration plots was 20.30 quintals per hectare, while that actual farm yield was only 7.60 quintals per hectare, showing a gap of 62.5 per cent. The potential farm yield of bajra was 11.67 quintals per hectare whereas on farmers' field the yield was 5.77 quintals per hectare and a resultant gap was worked out 50.5 per cent in bajra.

Johl (1984) in his presidential address to the 43rd Annual Conference of the Indian Society of Agricultural Economics (ISAE) pointed that the productivity gap between the experimental farms and the actual performance of different crops on the farmers' field ranged from 30 to 300 per cent. He opined that there was a tremendous potential for increasing productivity through better management of various inputs and cultivation practices with the available technology and given cropping pattern in different agro-climatic zones of the country.

While studying a yield gap analysis in rice production in Ratnagiri district, Fale *et al*. (1985) found a narrow gap of 2 quintals per hectare (3.83%) between the potential yield and potential farm yield in comparison to substantial gap of 52 per cent of (27 q/ha) between the potential yield and the actual yield realized on farmers' fields.

Madhavaswamy and Sesha Reddy (1987) estimated a fairly wide gap in the HYV sorghum yields in scarce rainfall zone of Rayalaseema. It was observed that the gap between the yield of best cultivator (25 q/ha) and the average yield of cultivators (11.92 q/ha) was high with 13.08 quintals per hectare while the yield gap was only 7 quintals per hectare between the best cultivator's yield and research station yield (32 q/ha). The yield difference of 20.08 quintals per hectare was observed between the experimental farms and average farms.

Singh and Reddy (1987) in a study on the adoption levels and constraints in the transfer of technology with respect to castor crop reported a big gap of 1108 kgs per hectare between the potential yield (1637 kg/ha) and average yield (529 kg/ha) in Southern Telangana zone of Andhra Pradesh. They suggested that the existing yield levels could be improved if the farmers follow all the recommended package of practices, since even the progressive farmers also failed to follow all the recommended package of practices.

Basavaraj (1988) studied the gap in cotton yield in Karnataka. The actual yield ranged from 1529.12 kgs per hectare on small farms of Dharwad district to 1666.43 kgs per hectare on large farms of Raichur district. The productivity of cotton on sample farms was far below that obtained on demonstration plots. The estimated yield gap was found to be 42.4 per cent and 43.95 per cent for Dharwad and Raichur districts, respectively.

Pandey and Tewari (1988) observed that the economic yield gaps in the progressive and backward categories of sugarcane growers were conspicuously very high in West Uttar Pradesh. The progressive farmers' yield (608 q/ha) and the average yield (403 q/ha) were computed to be 34.3 per cent and 56.4 per cent of the economic potential yield (925 q/ha). The authors suggested that greater reliance on production policy combined with the long run price support policy can help in raising yield levels and reduce the yield gap.

Jayaram (1988) analysed the yield gap in paddy and ragi (irrigated) in Mandya district of Karnataka. The estimated yield gaps between farmers' average yield and the potential farm yield were found to be 5.98 quintals per hectare (9.56 %) and 4.84 quintals per hectare (14.41 %) in case of paddy and ragi, respectively. Whereas yield gaps-I were about 1.28 quintals per hectare (2.01 %) and 5.55 quintals per hectare (14.18 %). It was concluded that the labour had the highest magnitude of influence on potential yield realization in paddy while in the case of *ragi* crop, seedrate, farm yard manure, fertilizers and labour had a significant influence on potential yield realization.

Holikatti (1991) estimated the productivity gap in rainfed chilli production in Karnataka. The productivity gap ranged from 52.25 per cent on large farms to 52.45 per cent on small farms, in Byadagi dry chilli production. He reported that Gap II ranged from 36.33 per cent on sample farms to 38.74 per cent on large farms while overall Gap II was 113 kgs per acre (38.07 per cent) which resulted largely due to biological and socio-economic constraints.

Pandey and Shanti Sarup (1994) conducted the operational research project (ORP) on yield gap analysis in Mohindergarh district (Haryana). It was observed that the index of yield gap II was minimum for wheat (21.90%) and maximum for gram (31.80%) while it was 25.80 per cent and 27.40 per cent for barley and mustard crops, respectively. The findings implied that the yield levels of wheat and barley could be raised by more than 8.5 quintals per hectare while that of gram and mustard by more than 3.50 quintals per hectare by adoption of recommended inputs.

Patil (1995) carried out the study on yield gap in groundnut in Dharwad district of Karnataka. The data were collected from a sample of 120 farmers. He found that the yield gap I was 50.22 per cent while the yield gaps II were 31.86 per cent and 27.11 per cent on small and large farms, respectively. Thus, the total yield gap ranged from 63.12 per cent on small farms to 62.20 per cent on large farms.

Reddy *et al*. (1996) implied that the actual yield of rice in Guntur district of Andhra Pradesh was about two-third of the potential yield obtained at the demonstration plots. They revealed that the yield gap II on small farms (2094 kg/ha) was maximum followed by medium (1806 kg/ha) and large farms (1532 kg/ha). It was suggested that the non-exploited potential yield of about 35-40 per cent could be achieved by increasing the actual yield levels by 50 per cent over the existing level of 36 quintals per hectare to reach the yield level of demonstration farms.

Nagabhushanam and Sridhara (1997) evaluated the productivity difference in paddy in Kundapur tahsil of Dakshina Kannada district. They revealed that there was a narrow gap of 8.63 per cent (Gap-I) between the research station yield (19 q/acre) and progressive farmers' yield (17.36 q/acre). The yield obtained by the average farmers was found to be only 12.40 quintals per acre which indicated the wider gap of 26.11 per cent as compared to the progressive farmers. Total yield gap was estimated to be 34.74 per cent. Gap II was attributed due to non-exposure of the technologies as well as the non-participation in educational activities which alarms the extension agency to take up the educational activities to reduce Gap II.

Gaddi (1999) conducted a study to ascertain the yield gaps and constraints in the production of major crops in North Karnataka. The indices of yield gaps were worked out to be 58.83 per cent, 57.43 per cent and 56.55 per cent for jowar, groundnut and cotton, respectively. He found that nearly 70 per cent of the potential farm yield in jowar and groundnut and 65 per cent of the potential farm yield in cotton were realized by the sample farmers.

Pandey (2000) made an attempt to examine the yield gap of wheat between the experimental yield and actual yield realized by the bulk of farmers in the Plateau region of Bihar. The study was based on the data collected from a sample of 45 farmers randomly selected from Kanke block of Bihar. The actual yields were observed to be 14, 15 and 18 quintals per hectare on marginal, small and medium size-groups of farms, respectively. The wheat yield varied from 38 to 51 quintals per hectare on the experimental farms under All India Co-ordinated Wheat Improvement Project while it was 25 to 42 quintals per hectare under Cropping Systems Project. He indicated that there existed a big gap as the experimental yield was 2 to 3 times higher than those on actual yields. Proper use of inputs was suggested to increase wheat production in the region.

Rao *et al*. (2002) estimated the magnitudes of yield gaps in the production of pulses in Andhra Pradesh. They revealed that the yield gap of 2177 kgs per hectare was highest in red gram (87%) followed by black gram 1941 kgs per hectare (58.3%). Genetic research should be promoted to achieve technology break-through to boost up the yield levels of pulses. The study suggested other strategies like low inputs technology and mass education of farmers in the new technology.

Naidu and Hunsigi (2003) studied the yield gap analysis of sugarcane crop in Karnataka considering the attainable cane yield on research farms and farmer's yield. The study concluded that wide yield and management gaps existed between research recommendations and farmer's practices. The yield gap varied from 4.9 to 42.2 tonnes per hectare in the study area. It was observed that the gap was lowest (4.9 t/ha) on Chikkodi soil while it was highest (42.2 t/ha) on Jamkhandi soils. The authors revealed that the yield gap was found to be wider in the area where fertilizer use deviation was wider. It was suggested to revalidate the existing fertilizer recommendations in the context of declining crop responses due to fertility degradation.

Borate (2005) conducted the study of yield gap analysis of sugarcane in Pune district. He observed about 34.13 per cent of yield gap between the potential yield and actual yield. There was about 6.92 per cent yield gap between the potential yield and potential farm yield only in comparison to 50.21 per cent yield gap between the potential farm yield and actual yield. This indicated a tremendous scope to improve the sugarcane production in the study area.

2.2 Factors contributing to yield gap

Using the output decomposition model many researchers have attempted to estimate the contribution of various factors responsible for yield difference in different crops.

Bisaliah (1977) decomposed the yield difference between two wheat production technologies in Punjab state into it's constituent sources. He observed that the technique of production contributed 15 per cent of the total gap in output. The increased use of inputs under Mexican wheat contributed about 25.5 per cent to the total difference in output. The inputs like fertilizers, capital and labour contributed 15 per cent, 8 per cent and 2 per cent, respectively.

Kalirajan (1980) studied the contribution of location specific research to productivity of paddy in Coimbatore district of Tamil Nadu State by using Cobb-Douglas type of yield function. The results indicated that the estimates of coefficients of labour, other inputs and capital were 0.03, 0.01 and 0.01, respectively; which were significant at 5 per cent level. This revealed that the yield could be increased only by small amounts by increasing the application of those inputs. It was found that the higher yield inherent in the genetic characteristics of location specific modern varieties, and their other biological characteristics which had a positive influence on pest control, were the two major factors identified as explaining the varietal yield gap.

Gundu Rao *et al*. (1985) applied the Cobb-Douglas type of production function to the input-output data while decomposing the yield gap between local and improved varieties of *ragi* grown in Bangalore district. The improved variety contributed 45 per cent more output per hectare than the local variety of *ragi*. In view of the conclusions, about 33 per cent of the productivity gap was attributed to technical change while the capital services accounted for about 13 per cent of productivity gap in *ragi*.

Basavaraj *et al*. (1990) made an attempt to estimate the extent of contribution of various factors to the yield gap in cotton in Raichur district (Karnataka), with the help of decomposition analysis. The estimated yield gap in cotton in the study area was found to be more than 50 per cent. The findings of the decomposition analysis revealed that the inappropriate techniques of production adopted by the farmers contributed significantly to about 43 per cent and 27 per cent to the estimated yield gap on large and small farms, respectively. This implied that a large portion of the potential farm productivity in cotton could be exploited by adopting better techniques of production. The sub-optimal use of inputs on the farmers' fields vis-à-vis demonstration plots was found to depress the productivity to the extent of 32 per cent and 14 per cent, respectively, on small and large farms. The findings of the study focus on the importance of extension personnel in respect of transfer of technology to the farmers that would help to reduce the yield gap.

Holikatti (1991) conducted the study on the yield gap in the production of rainfed chilli in Karnataka. By employing Cobb-Douglas production function, the total output was decomposed into constituent components. The output decomposition analysis has suggested that there was 106 per cent growth in chilli output per acre with the introduction of new technology. Of this total change in output, about 92 per cent was found to be contributed by technical change and 13.96 per cent by difference in land size, FYM, plant protection chemicals and fertilizers.

Chowdhary *et al*. (1993) analysed the reasons for yield gap in groundnut crop in Ananthpur district of Andhra Pradesh. It was found that the contribution of optimum time of sowing was as high as 64.5 per cent of maximum farm potential and the yield could be increased by 53 per cent by applying balanced fertilizers of nitrogen and phosphorus. Application of fertilizers through fertilizer-cum-seed drill or through an attachment to the country seed drill increased the yield of groundnut by 18 per cent. Thirty-four per cent of the increased yield was obtained by cultivating high yielding varieties of the crop under study. The recommended plant protection measures contributed to the extent of 40 per cent whereas the cultural practices such as clean cultivation and use of optimum seedrate contributed to about 15 per cent and 17 per cent, respectively.

Reddy *et al*. (1996) identified the factors influencing yield gap in rice in Guntur district of Andhra Pradesh. The results of the study revealed that the gap between recommended levels of all key inputs was found to be the major reason for wide gap in yield between demonstration farms and actual farms. The yield gap for small farmers was mainly due to lower use of all the inputs such as human labour, bullock labour, seedrate, chemical fertilizers like N, P, K and pesticides while for large farmers the gaps in all the inputs except nitrogen and human labour contributed to yield gap in rice. The authors inferred that the yield gap could be minimized by the adoption of recommended levels of technological innovations especially input levels for enhancing yields under actual farms.

Patil *et al*. (1997) estimated the contribution of different factors to yield gap in groundnut production in Dharwad district of Karnataka State. With the help of decomposition analysis, it was observed that there existed 28.69 per cent of yield gap between the research farms and sample farms. The contribution of techniques of production and input use differences to the productivity gap in groundnut were found to be 3.42 per cent and 25.82 per cent, respectively. This meant that there was a vast scope for exploiting the greater yield levels on the farmers' fields by increasing the input use levels. The sub-optimal use of human labour contributed for the highest share (14.36%) among all the inputs. However, the contribution of plant protection chemicals was negative. This implied that a higher output could be obtained by reducing the expenditure on this input.

Gaddi *et al*. (2002) in their study on yield gap in cotton production in North Karnataka analysed the contribution of various sources to the yield gap. It was found that the difference in cultural practices and input use gaps between the farmers' fields and the demonstration plots contributed about 28 per cent and 15 per cent to the yield gap, on the overall category of farmers' field. Thus there was a more scope to raise the cotton productivity by improving the techniques of production rather than by raising input use levels. Further, the analysis of contribution of various inputs to the yield gap revealed that the contribution of human labour (11.91 per cent) was comparatively more on large farms, while the contribution of bullock labour was more (10.25 per cent) on small farms than any other inputs. However, the possibility of exploiting the untapped potential farm yield in cotton by using more of seed and capital inputs was rather impossible as both the inputs were excessively used.

Kamruzzaman *et al*. (2002) identified the factors affecting yield gap of Boro rice producers at Narshingdi district of Bangladesh. It was observed that low water retention capacity of the soil (34.09%), poor quality seed (22.73%) and sub-optimal use of cowdung, fertilizers and irrigation (20.45%) were the major factors contributing to low yield of the crop. About 13.64 per cent and 9.09 per cent farmers reported the yield gap constraints like lack of irrigation water and poor cultural operations, respectively. It was concluded that the yield gap may be reduced if the farmers cultivate in high land, clay loam or sandy loam soil with good drainage facilities and own sources of seed. The logit analysis showed that the gap may be reduced by proper education and farming experience to the farmers as well as by application of recommended seedrate and cow dung.

2.3 Economic comparison of farmers' yield with potential and potential farm yield

Barker *et al*. (1977) have reported yield constraints for 2 wet seasons and 2 dry seasons at three locations of the Philippines. In the wet season, the yield gaps ranged from 0.4 to 2 tonnes per hectare with fertilizer and insects control responsible for nearly equal amounts in most locations. The yield gaps ranged from 0.9 to 2 tonnes per hectare in the dry season. The maximum input use cost was 2 to 4 times more than the farmers' input use level in most of the wet season experiments and about half the dry season experiments. Package of inputs slightly higher than farmer's input use level had increased profits. But yields were increased by only about 0.3 tonne per hectare in the wet season and by about 1.0 tonne per hectare in the dry season.

Herdt (1980) in his paper on "On farm yield constraints of modern varieties of rice" analysed the experimental yield and farmers' yield to assess whether it was profitable for the farmer to change from his current to the higher input technology. The results of 239 wet season and 205 dry season trials conducted at different locations in Bangladesh, Sri Lanka, Indonesia, Taiwan, Thailand and Philippines showed that the incremental output value of dry season trials was about \$ 192 per hectare which was greater than that of wet season trials (\$ 141/ha). The per hectare input use costs at farmers' fields were \$ 85 and \$ 87 in wet and dry seasons, respectively, while it was about \$ 118 and \$ 119, respectively at wet and dry season trial farms. The increased net returns from high inputs in the dry season exceeded those in wet season. The results of the economic analysis indicated that the most profitable opportunity for increased yield was in the dry season through the use of researchers' fertilizer levels instead of the farmers' fertilizer levels.

Rangaswamy (1982) focused on the profitability of the improved technology in the production of coarse grains like jowar and bajra. The data were collected from two centres *viz*., Hissar in Haryana and Kovilpatti in Tamil Nadu for the period between 1976-77 to 1978-79. He observed that bajra crop at demonstration farms incurred losses in the first year and obtained small net returns of only Rs. 11.41 per hectare in the other two years. But the average net returns for three years were only Rs. 6.39 per hectare against a loss of Rs. 17 per hectare for the control plots. The cost of production on demonstration farms was 1.75 times of that on the control plots. In case of jowar crop, the gross returns obtained from hybrid variety (CSH-6) on demonstration farms were Rs. 2731.12 per hectare against those obtained from local variety in control plots which were Rs. 1501.40 per hectare. Net returns obtained from local variety were only Rs. 400 per hectare (control) in comparison to Rs. 1126.76 per hectare obtained from cultivating CSH-6 variety on demonstration plots. The findings indicated that adoption of improved technology on demonstration plots gave more returns as compared to those obtained with traditional technology in control.

Fale (1983) analyzed the constraints operating against the realization of higher rice yields on the farmers' fields in Ratnagiri district. He reported that per hectare cost and returns over working expenses were higher on national demonstration plots as compared to sample farms. The returns over working expenses were estimated to be Rs. 4918.79 per hectare on national demonstration plots than that obtained from the sample farms (Rs. 1543.73/ha). The per hectare increased output value on national demonstration plots was Rs. 5663.56 and Rs. 5318.46 than those on overall farms and farms with high yielding varieties, respectively. Thus, the increased net benefits from the national demonstration farms was Rs. 3375.06 over overall farms and Rs. 3081.74 over HYV farms. The benefit cost ratio of increased inputs on national demonstration plots came to 2.47 over input levels of all farms and 2.32 over the farms with HYVs. It clearly indicated that the farmers can increase their returns by increasing input levels.

Singh *et al*. (1988) estimated the gaps in expected and actual crop yield, investment and returns of major *rabi* crops in the watershed area of Madhya Pradesh. The yield gaps were estimated to be 91.00 per cent, 71.95 per cent and 53.68 per cent in case of wheat, gram and sugarcane crops, respectively. The investment gaps were found to be minimum of about 16.60 per cent in case of gram followed by 35.73 per cent and 45.08 per cent in sugarcane and wheat, respectively. The expected per hectare net returns were estimated to be Rs. 2115, Rs. 6215 and Rs. 1268 in three crops stated above, respectively, whereas the actual net returns were found to be Rs. 1720.10, Rs. 712.63 and Rs. 571.59, respectively in wheat, gram and sugarcane production. Thus, the gaps in net returns were computed to be 18.67 per cent in wheat crop, 88.53 per cent in gram and 95.30 per cent in sugarcane crop.

Singh and Sen (2004) estimated the cost functions for sugarcane production in Bijnor district of Uttar Pradesh. In the study, the estimate of total fixed cost was Rs. 7423 per hectare which was the same for all output levels. It was examined that the per hectare total cost incurred by the best sugarcane growers, progressive farmers and backward farmers were Rs. 21407, Rs 17943 and Rs. 16293, respectively. Total cost of inputs was found to be increasing with the increase in the output levels. The estimate of the lowest average cost was found to be Rs. 23.04 per quintal, which corresponds to the sugarcane output level realized by the best sugarcane growers. In view of the results, it was suggested to encourage the less efficient farmers to reach the yield level of 1000 quintals per hectare realized by the best sugarcane growers.

2.4 Constraints in yield gap

Gomez (1977) studied the constraints responsible for the difference between potential and farm level yields of rice. These constraints were identified under two main heads – biological and socio-economic constraints. The biological constraints indicated the sub-optimal use of production inputs needed for higher yields and the socio-economic constraints are related to farmers' behaviour, their technical knowledge, credit facilities, supply and distribution of the production inputs.

Barker and Pal (1980) observed that uneven rainfall, weather conditions, lack of proper technical know-how and some socio-economic constraints that farmers were constantly facing, were the major obstacles to increase rice production in Eastern India. On the basis of the results of the study, they suggested that rice productivity could be increased by improving water control and developing rice varieties tolerant to the prevailing frequent floods and drought conditions.

Herdt (1980) examined the constraints which prevented the farmers of South-East Asia from achieving the yield potential of modern varieties of rice crop. In the study, the physical and climatic conditions, soil and water management, institutional constraints like market prices of paddy, interest rates and tenure conditions were assumed to be given. Fertilizer use and insect control were found to affect the yield levels to a marked extent.

Panghal *et al.* (1985) in a study on yield gaps in Haryana concluded that capital requirement in modern agricultural technology have substantially increased the magnitude of risk of crop loss. It was observed that the farmers inclined towards the adoption of new crop technology that ensured stable and higher yield levels.

Madhavaswamy and Sesha Reddy (1987), while studying the constraints in sorghum production in scarce rainfall zone of Rayalaseema, identified the major constraints such as lack of capital, non-use of suitable varieties, poor quality of seed and straw, problem of striga and lack of technical knowledge, all of which were responsible for non-adoption of high yielding variety and consequent presence of wide yield gap between the potential farms and the actual farms.

Jayaram (1988) identified the major constraints for getting higher yields of paddy and ragi in Mandya district of Karnataka. The findings of the study revealed that the lack of adequate moisture and non-availability of labour were the most serious constraints in achieving the potential yields, evidenced by the fact that 37 per cent and 30 per cent of the respondents expressed the respective constraints. About 15 per cent of the respondents were unhappy about the availability of inputs and an equal number felt that the attack of pests and diseases were responsible for the lower yields.

Holikatti (1991) analysed the constraints in rainfed chilli production in Karnataka. He observed that majority of the farmers (96.67%) experienced the problem of pest and diseases followed by unfavourable climatic factors, difficulty in obtaining inputs and labour shortage during peak crop season. It was suggested to control the pest and diseases through proper plant protection measures for the purpose of attaining high chilli yields.

Pandey and Shanti Sarup (1994) made an attempt to find out the constraints in crop productivity in Mohindergarh district of Haryana. The constraints hindering realization of higher yields of wheat, barley, gram and mustard were reported such as water management, non-availability of location specific drought and pest resistant varieties, lack of technical knowledge and low soil fertility. They suggested fixing up the responsibility of scientists, administrators, extension personnel and involvement of the agencies providing infrastructural facilities.

Reddy *et al*. (1995) carried out the opinion survey of cotton growers in Guntur district of Andhra Pradesh to identify the constraints for low yields. The results indicated that the pest incidence was expressed as a major constraint by the majority of farmers (17.5 per cent), while weed infestation and non-availability of irrigation were reported as other technological constraints. In addition to these, the socio-economic constraints like lack of technical guidance, lack of owned capital, high cost of inputs, non-remunerative output prices, lack of awareness about pesticide use and non-availability of adequate credit in time were also reported by the sample farmers. In view of the findings, certain policy options for increasing yield levels were identified as subsidized input supply, credit supply providing technical guidance, organizing cooperative marketing and providing storage facilities, etc.

Gaddi *et al*. (2002) focused on the constraints faced by the farmers in the production of *rabi* sorghum in Karnataka. The study revealed that more than 50 per cent of respondents opined substandard and costly chemical fertilizers and plant nutrients as a major constraint. In addition to this, soil problem (26.25%), difficulty in obtaining desired seeds (45.00%), unfavourable climatic conditions (46.25%), incidence of pest and diseases (43.75%) and labour problem during peak crop season (45.00%) were the major constraints responsible for yield gap in *rabi* sorghum production.

Borate (2005) reported various constraints faced by sugarcane growers in Pune district, while analyzing the yield gap in sugarcane production. High cost and scarce labour for adopting tillage practices, high cost and non-availability of FYM, farm yard manure, costly fertilizers, inadequate supply of electricity and load shading, costly drip irrigation system were the major constraints faced by more than 60 per cent of sugarcane growers.

The review of literature indicated that the yield gaps existed in all the crops. It was revealed that very few studies have been conducted on the yield gap analysis in rice crop in the Konkan region. Hence, such study was undertaken with the specific objectives stated earlier.

CHAPTER IV

METHODOLOGY

This chapter is devoted to explain the plan of investigation, sampling design, location of the study, nature and sources of data and the analytical techniques employed, which are important to judge the quality of findings. This chapter is divided into following parts.

4.1 Sampling procedure

4.2 Collection of data

4.3 Reference period

4.4 Analysis of data

4.1 Sampling procedure

The sampling procedure followed in the present study is described below.

4.1.1 Selection of tahsils

Raigad district is said to be rice bowl of Maharashtra state. Two tahsils *viz*., Karjat and Roha were selected randomly for the study.

4.1.2 Selection of villages

A list of villages in each of the selected tahsils alongwith the area under rice crop was prepared with the help of revenue records. Then three villages from each tahsil were selected on random basis. Thus, total six villages were selected for this study.

4.1.3 Selection of rice growers

A list of rice growers from each selected village was obtained from the revenue records maintained at village level. Ten farmers from each village were selected randomly. Thus, final sample from six villages consisted of sixty farmers as shown in the following table.

Table 4.1 Tahsilwise distribution of villages and rice growers

Sr. No.	Name of the tahsil	Name of village	Number of growers
1.	Karjat	Vadap	10
		Haliwali	10
		Dahigaon	10
2.	Roha	Amdoshi	10
		Vangani	10
		Ambeghar	10
		Total	**60**

The selected farmers were further grouped on the basis of their land holdings as given below :

a) Small farms (upto 1 ha)

b) Medium farms (1 – 3 ha)

c) Large farms (above 3 ha)

Thus, the total sample size of 60 rice growers comprised of 31 small, 17 medium and 12 large farmers.

4.2 Collection of data

The primary data were collected from the selected farmers by survey method. The sample farmers were interviewed personally with the help of pretested schedule specially designed for the purpose (Appendix III).

The field level data i.e. information on use of various inputs *viz.*, seed rate, labour utilization, manure, fertilizers and yield obtained from rice crop, etc. were collected from the sample farmers. The particulars regarding the demonstrations in rice and yield of research station were obtained from the Regional Agricultural Research Station, Karjat.

For getting information about research station yield, data were obtained from one of the experiments conducted at Regional Agricultural Research Station, Karjat in *Kharif*, 2004. The experiment was conducted for comparing the effect of different manure and fertilizer treatments on yield levels of different rice varieties.

4.3 Reference period

The information and data of the sample farmers as well as demonstration plots for present study pertains to the *Kharif* season of 2005.

4.4 Analysis of data

The extent of use of inputs and output obtained in rice cultivation and the yield gap and input use gaps were estimated by simple tabular method of analysis with the help of basic statistics like mean percentages etc. by keeping in view of the above objectives.

4.4.1 Yield gap

The yield gaps were estimated by using the methodology developed by International Rice Research Institute, Philippines (Gomez, 1977). The methodology adopted for estimation of yield gap is given below,

i) Total Yield Gap (GT) = $Y_p - Y_a$

Where,

Y_p – Potential yield (yield realized at research station)

Y_a – Actual yield (yield realized on farmers' field)

The total yield gap has been split into two components *viz.*, Yield Gap-I and Yield Gap-II.

ii) Yield Gap –I = Y_p - Y_d

Where,

Y_p = Potential yield

Y_d = Potential farm yield (yield realized at demonstration plots)

iii) Yield Gap – II = Y_d - Y_a

Where,

Y_d = Potential farm yield

Y_a = Actual yield

4.4.2 Indices of yield gaps

1) Index of yield gap, (IYG)

$$IYG = \frac{Y_p - Y_a}{Y_p} \times 100$$

2) Index of realized potential yield (IP)

$$IP = \frac{Y_a}{Y_p} \times 100$$

3) Index of realized potential farm yield (IF)

$$IF = \frac{Y_a}{Y_d} \times 100$$

It may not possible for all the farmers to raise the productivity of crop on their farms to the level of research station. However, it would be possible to attain the demonstration plot yield (potential farm yield) level by the average farmers. Therefore, in the present study emphasis was given on yield gap-II only.

4.4.3 Production function analysis

The transformation of inputs into output is described by the production function. The production function is described below.

$$Y = f (X_1, X_2, X_3, \ldots, X_n)$$

Where Y is the per hectare output of crop with a given set of inputs X_1, X_2, X_3, … X_n per hectare.

The Cobb-Douglas type of production function has been widely used in most of the studies. Cobb-Douglas specifies a homogenous function that provides scale (parameter) factor enabling one to measure the returns to scale and to interpret the elasticity coefficient with a relative ease. But at the same time it makes several restrictive assumptions like constant elasticity coefficients implying constant shares for the input, unitary elasticity of substitution between inputs, function becomes linear in logarithmic form and output expansion path passes through origin.

4.4.3.1 Functional form

The Cobb-Douglas type of production function specified below is used for the present analysis.

$$Y = aX_1^{b1}\ X_2^{b2}\ X_3^{b3}\ X_4^{b4}\ X_5^{b5}\ X_6^{b6}\ X_7^{b7}\ U_t$$

Where,

Y = Yield of rice crop (q/ha)

A = Intercept, a scale parameter

X_1 = Human labour (days/ha)

X_2 = Expenditure on bullock and machine power (Rs./ha)

X_3 = Seed rate used (both family and hired)

X_4 = Expenditure on organic manures (Rs./ha)

X_5 = Expenditure on N fertilizer (Rs./ha)

X_6 = Expenditure on P fertilizer (Rs./ha)

X_7 = Expenditure on K fertilizer (Rs./ha)

U_t = Error term

b_i = Output elasticities of respective inputs

$\sum b_i$ = Returns to scale.

The significance of each of the estimated values of regression coefficients (b_i) were tested with the help of 't' test and goodness of fit was judged on the basis of coefficient of determination (R^2).

The Cobb-Douglas type of production function was converted into a log linear form and the parameters were estimated using the Ordinary Least Square (OLS) technique.

The log-linear forms of estimated Cobb-Douglas production functions are as follows :

$$\ln Y_1 = \ln A_1 + \sum_{i=1}^{7} b_{1i} \ln X_{1i} + U_1 \qquad \ldots (1)$$

$$\ln Y_2 = \ln A_2 + \sum_{i=1}^{7} b_{2i} \ln X_{2i} + U_2 \qquad \ldots (2)$$

Where,

Subscripts 1 and 2 in the above equations represent the sample farms and the potential farm, respectively. b_{1i} and b_{2i} represent output elasticities of i^{th} input on the sample farm and demonstration farm, respectively.

4.4.4 Decomposition analysis

The output decomposition model as developed by Bisaliah (1977) was used for analyzing the contribution of various constituent sources to the yield gap between the potential farm and the farmers' field.

Taking difference between (2) and (1), we get

$$\ln Y_2 - \ln Y_1 = (\ln A_2 - \ln A_1) + \sum_{i=1}^{7} (b_{2i} \ln X_{2i} - b_{1i} \ln X_{1i}) + (U_2 - U_1) \quad \ldots(3)$$

By adding some terms, subtracting same terms, and rearranging terms in (3) the following decomposition model is arrived at

$$\ln Y_2 - \ln Y_1 = (\ln A_2 - \ln A_1) + \sum_{i=1}^{7} (b_{2i} - b_{1i}) \ln X_{1i} + \sum_{i=1}^{7} b_{2i} (\ln X_{2i} - \ln X_{1i}) + (U_2 - U_1) \quad ..(4)$$

By using logarithmic rule, equation (4) becomes

$$\ln (Y_2/Y_1) = \ln(A_2/A_1) + \sum_{i=1}^{7} (b_{2i} - b_{1i}) \ln X_{1i} + \sum_{i=1}^{7} b_{2i} \ln (X_{2i}/X_{1i}) + (U_2 - U_1) \quad ..(5)$$

The decomposition equation (5) involves decomposing the logarithm of ratio of per hectare potential farm yield and the actual yield on sample farms (LHS). This is approximately a measure of percentage change in per hectare output between the demonstration plots and the farmers' field.

The summation of first and the second terms on the right hand side of the decomposition model together represented the productivity difference between the potential farm and the sample farm, attributable to the difference in the cultural practices. The third term provided the yield gap between the potential farm and the farmers' field attributable to the input use gaps.

CHAPTER VI

SUMMARY AND CONCLUSION

Rice (*Oryza sativa* L.), is an important food grain crop to acquire self-sufficiency in food grain production for the increasing population in India. It was cultivated on an area of 42.40 million hectares with the production of 88.28 million tonnes in the year 2003-04 in India. Technology break through in the field of agriculture has resulted in the spectacular performance in rice production in the country, but with regards to average productivity, such a phenomenon was not forthcoming. The average rice yields on actual farms are lower than their potential levels. The difference between the potential farm yield and actual farm yield is known as 'yield gap' and factors responsible for it are termed as 'yield constraints'. Even though large scale verification trials and demonstrations are conducted to test the feasibility and suitability of the technology before it is released to farmers for adoption, there exists a wide yield gap between the potential farm yield and actual farm yield. Thus, quantification of this gap and identification of factors responsible for existence of such gap at micro level, i.e. on farmers' fields is essential. The present study is undertaken in Raigad district of Maharashtra which is said to be 'rice bowl of Maharashtra.' Raigad district accounts for 8.24 per cent area and 18.24 per cent production of rice in Konkan region. Rice occupied about 1.25 lakh hectares area with the production of 2.56 million tonnes in *Kharif* season in 2002-03. The average yield of *Kharif* rice was 2.06 tonnes per hectare in the district which was higher than that of Konkan region (1.73 t/ha). Even though a need was felt to carry out the yield gap analysis in *Kharif* rice as the scope for increasing crop production can only be achieved through increased productivity. Therefore, the study entitled "An economic analysis of yield gap in rice in Raigad district (M.S.)" was undertaken with following objectives:

i) To estimate the input gap and productivity gap in rice.

ii) To identify the factors responsible for yield gap and to estimate their contribution in yield gap.

iii) To study the economic comparison between potential farm yield and actual farm yield.

iv) To identify the constraints responsible for yield gap.

The present study was undertaken in Roha and Karjat tahsil of Raigad district, which were selected on random basis. From each tahsil three villages and from each village ten rice growers were selected randomly. Thus, final sample consisted of sixty rice growers. The information for the agricultural year 2004-05 was obtained through personal interview of the sample farmers with the help of specially designed schedule for the purpose of this study. The data pertaining to the demonstration plots and research station's yield were obtained from Regional Agricultural Research Station, Karjat, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli. The methodology of yield gap analysis developed by International Rice Research Station, Philippines (IRRI) was used to estimate the magnitude of yield gap in rice. Tabular analysis was used to quantify the differences in inputs used, for economic comparison and to identify the constraints responsible for yield gap. Cobb Douglas production function was applied to estimate the effect of different factors on yield gap. The extent of contribution of input gaps to yield gap was examined by means of decomposition analysis.

The findings of the study are summarized as under:

1. General information of farmers

Average age of the farmers was 42.55 years and average educational score was 7.96. The average size of the family was 5.22 whereas the persons working on farm were 2.53. Land is an important factor of production. The average operational holding was 2.76 hectares. In the present study, it was observed that the per farm average land holding in the study area was 1.76 ha. The proportion of land under cultivation was 77.27 per cent and about 15.91 per cent land was observed to be unsuitable for cultivation.

2. Cropping pattern

The cropping pattern was dominated by rice crop alone in *Kharif* as well as summer seasons. Irrigation facilities available in the area have made possible for the farmers to cultivate rice in summer season. The gross cropped area and net sown area were found to be 2.68 ha and 1.44 ha, respectively. Much higher cropping intensity of about 186.11 per cent was observed on the sample farms.

3. Assets position

Per farm investment in farm assets possessed by the sample farmers was found to be Rs. 105720.58. The share of land value was maximum in total value of assets (67.49 %). The investment made in livestock, farm buildings including cattle shed and implements were worked out to 12.48 per cent, 13.53 per cent and 6.50 per cent, respectively.

4. Input use gaps in rice

The observation regarding utilization of inputs use indicated that the levels of inputs used on demonstration farms were higher as compared to that at farmers' level, with respect to all production inputs except that of seed rate. There was much higher gaps in the use of plant nutrients like phosphorus and potassium which was found to be a major factor responsible for yield gap in rice. It is observed that the farmers expend more on N fertilizers and neglect the use of P and K elements which was an important cause for increasing the output. This necessitates the education of farmers regarding balanced application of plant nutrients. It can be possible with the help of effective extension services.

5. Magnitude of yield gaps in rice

The potential yield of rice was estimated to be 46.68 quintals per hectare against the actual farm yield of 31.29 quintals per hectare at an overall level. The respective yield levels were 30.99 quintals, 31.84 quintals and 31.26 quintals per hectare in case of small, medium and large farms. The potential farm yield was observed to be 44.57 quintals per hectare. The comparison of the potential yield, potential farm yield and actual farm yield showed that there was a considerable gap between the potential farm yield and actual farm yield. This gap was termed as 'extension gap' which could be minimized by effective transfer of recommended technology.

Per hectare total yield gap in rice was estimated to be 15.39 quintals (32.97%) on case of overall farms with 15.69 quintals (33.61%) on small, 14.84 quintals (31.79%) on medium and 15.42 quintals (33.03%) on large farms. The yield gap-I was only 2.11 quintals per hectare (4.52%) and the yield gap-II was 13.28 quintals per hectare (29.80%) in case of overall farms. Relatively smaller size of yield gap-II was noticed on medium farms (12.73 q/ha.) as compared to 13.58 quintals per hectare on small and 13.31 quintals per hectare on large farms. Yield gap-I was partly due to environmental differences and partly due to non-transferable component of technology. Yield gap-II was largely the result of biological and socio-economic constraints.

The farmers exploited about 67.03 per cent of potential yield of rice. The medium farmers were found to be better off in exploiting the potential yield when compared to small and large farmers. The farmers were found to be successful in exploiting about 70.20 per cent of potential farm yield in rice crop. This clearly showed the possibility of increasing rice yield by at least one-fourth of its present level. The exploitation of potential farm yield of rice was 69.53 per cent, 71.44 per cent and 70.14 per cent in case of small, medium and large farms, respectively.

6. Factors contributing to yield gap in rice

The functional analysis of yield gap in rice revealed that the gap between the recommended levels of all key inputs at demonstration farms and actual input use levels was found to be a major reason for wide variations in realizing the potential farm yield on sample farms. An inference can be drawn from the results that yield gap-II could be minimized by adoption of recommended levels of key inputs.

The decomposition analysis revealed that the difference between the potential farm yield and actual yield was 37.28 per cent on small, 34.46 per cent on medium and 29.82 per cent on large farms with average 31.43 per cent. This implied that more than 30 per cent of the potential farm yield was left untapped by the farmers. Only the difference in input use was found to contribute the yield gap in rice. The contribution of inappropriate techniques of production was found to be negative at an overall level. Input use gap at an overall level was found to be contributed about 31.95 per cent to yield gap in rice. It was about 37.13 per cent on small, 34.59 per cent on medium and 32.73 per cent on large farms.

7. Economic comparison

The economic comparison indicated that per hectare cost was higher on the demonstration farms as compared to sample farms. The returns over working expenses were Rs. 7486.01 on demonstration farms and Rs. 2184.89 on overall farms. The increased output value and increased cost on demonstration farms were Rs. 8731.43 and Rs. 3430.78 over the actual farms. Thus, increased net benefit from the demonstration farms came to Rs. 5301.12 over actual farms. The benefit cost ratio of increased inputs on the demonstration farms was estimated to be 2.55 over input levels of all farms indicating that the farmers can increase their returns by increasing input levels.

8. Constraints responsible for yield gaps

The major constraints perceived by the farmers in realizing the potential farm yield on their farm were abnormal distribution of rainfall, high cost of fertilizers, labour problem, costly pesticides, shortage of funds, inadequate supply and high cost of seed and non-availability of all the critical input seed, fertilizers and pesticides in time. Other major constraint in rice cultivation was that the farmers are not getting proper market prices.

Conclusion

On the basis of the findings of the study following conclusions are drawn

1. The gap between the yield on research station and those obtained on the demonstration plots (Yield gap-I) was quite narrow (2.11 q/ha or 4.52%). However, there was a wide gap of 13.28 quintals per hectare (29.80%) between the potential farm yield and actual farm yield.

2. The differences in human labour, bullock and machine power, manures and plant nutrients between the demonstration farms and actual farms were the important factors influencing the yield gap-II. Comparatively smaller yield gap was observed in case of medium farms.
3. The variation in the use of key inputs was a major reason for yield gap in rice. The contribution of the inappropriate techniques of production to yield gap estimated to be negative at an overall level.
4. The contribution of phosphorus gap was estimated to the tune of 16.52 per cent which was the major factor in increasing output level.
5. Farmers have used nitrogenous fertilizers as per recommended dose but the use of phosphorus and potash was found to be less which is also a factor responsible for low yield of rice.

Policy implications

Based on the findings of the study and general observations at the time of data collection, following policy implications are suggested.

1. The findings of the study clearly indicated that yield gap was attributable to sub-optimal use of inputs at farmers' level compared to that on demonstration farms. Hence, additional plant nutrients especially phosphorus, potassium and manures could be applied to obtain substantial productivity gains on the farmers' field.
2. The farmers must be educated on the balanced application of plant nutrients and encouraged to adopt all the recommended practices. This alarms the extension agencies to take up such educational activities in order to enhance the rice productivity on actual farms.
3. Rearranging the supply of all critical inputs like seed, fertilizers and pesticides in the rice zone would help the farmers to narrow down the yield gap in rice.

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CHAPTER III

SOCIO-ECONOMIC BACKGROUND OF RAIGAD DISTRICT

This chapter depicts the agro-physical and socio-economic conditions prevailing in the Raigad district, which was selected for the present study. The study of socio-economic background is necessary to understand the economic implications of physical conditions under which production is carried out. A brief account of the socio-economic conditions prevailing in the district is given so as to have a better understanding of the region and also to help in the interpretation of results and drawing conclusions or inferences.

3.1 Location

Raigad district forms a part of Konkan plain, which lies between 17^0 51′ and 19^0 80′ north latitude and 72^0 51′ and 73^0 40′ east longitude. The district has the coastline of about 240 km. The average north-south extension of the Raigad district is about 160 km while the east-west extension varies between 24 and 48 km.

3.2 Boundaries

Raigad district is formed partly by the foot hills zone and partly by the watersheds of major Sahyadrian scrap in the east beyond which lies the Pune district by a boundary that is mainly administrative. Arabian sea is to the west and Ratnagiri district is to the South direction of the district. Raigad district is adjoined by Satara district for about 30 km in the south-east, Thane district is at the north and Greater Mumbai lies in the north-west.

3.3 Topography

Raigad district can be divided into three natural zones from the point of topography as given below:

a) The coastal zone accounts for 18.8 per cent of the total area of the district. This zone consists of Uran, Alibag, Murud and Shrivardhan tahsils. It is marked by rice cultivation in the low lying areas and the plantation of coconut and betel nut.

b) The central zone covers about one-third of the district area. It has fertile land in the low-lying areas which are used for cultivation of rice and the millets like nagli and vari which are grown on hill-slopes.

c) The hilly zone comprises of eastern part of Karjat and Khalapur tahsils, the north-east corners of Mangaon and Mahad tahsils and Sudhagad and Poladpur tahsils. This zone has good forest. The Sahyadrian ranges on the eastern boundary have a highly uneven surface area and agricultural poor land. The low lying area in Mahad and Mangaon tahsils are fertile and rice is taken in *Kharif* and summer seasons in some area due to availability of irrigation facilities.

3.4 Soils

The sub-soil stratum consists of 'Deccan Trap' rock which is completely impervious to percolation of water, thereby causing an acute shortage of water in the summer season, eventhough this region receives heavy rainfall on the hill slopes. The reddish soil is used for growing grasses. The shell sands are found near the coast, which are suitable for coconut and betelnut plantation. The reddish brown and coffee brown soils are excellent for rice cultivation and are capable of producing second crop. The distribution of soil by types is

a) Course-shallow soil trap original 35.2 per cent.

b) Laterite and lateritic soils 39.5 per cent.

c) Coastal alluvial and coastal saline soil 25.3 per cent.

3.5 Climate and rainfall

The climate of Raigad district is typical to that of the west-coast of India with plentiful and regular monsoon rainfall. The weather is oppressive in hot months. Humidity is high throughout the year ranging from 65 to 80 per cent. The summer season from March to May is followed by the south-west monsoon season from June to September. The period from December to February is winter season. The highest and lowest temperatures recorded in the year 2001 were 40.4^0 C and 16.1^0 C, respectively. The district receives rainfall ranging from 2000 mm to 4000 mm. The highest rainfall in the district was 3638.7 mm at Matheran, whereas the lowest normal rainfall (1837 mm) at Uran during the year 2003. Hilly terrains of the district receives higher rainfall than that at coastal part.

3.6 Rivers

The major rivers flowing through this district are Ulhas, Patalganga and Amba at Northern part, Kundalika in Central Zone and Savitri, Kal and Ghod in Southern part. All these rivers rip in the Sahyadri hills and have westward flow. Through these rivers rainwater flow towards Arabian sea. These rivers have short length of water flow. Due to entry of sea water, most of the rivers are not used for irrigating the crops.

3.7 Area and population

The total geographical area of the district is 7148 sq.km., which accounts for 2.32 per cent of total geographical area of Maharashtra State. According to 2001 population census, total population of the district was 22,07,929 (22.07 lakhs). Out of total population, male and female population was 50.62 per cent and 49.38 per cent, respectively. The population density per square kilometer was 309. The rural population accounted for 75.80 per cent of total population of the district and 24.20 per cent population was from urban area. The proportion of female to male population was 975 females per thousand of male population. The economic classification of population shows that 41.40 per cent were workers. Among workers, 28.55 per cent were cultivators, 20.36 per cent were agricultural labour and 2.66 per cent were cottage industry workers and 48.43 per cent people were engaged in other works.

3.8 Literacy

As per 2001 census, literacy in the district was 77.03 per cent. Out of total male and female population, 86.15 per cent males and 67.75 per cent females were literate in the Raigad district. The literacy percentages in rural and urban parts of the district were about 73.78 per cent and 87.06 per cent, respectively. Uran tahsil has the highest literacy (82.69%) while the lowest literacy is observed in Sudhagad tahsil (65.59%).

3.9 Land utilization

Land utilization in Raigad district is given in Table 3.1.

As shown in Table 3.1, according to 2002-03 statistics, the total geographical area of the district was 687 thousand hectares. Out of the total area, the proportion of net sown area was only 29.84 per cent. Area sown more than once constituted 15.12 per cent to net sown area. The proportion of irrigated area to net area sown was only 5.85 per cent. Raigad district has large tracts of forests, barren land and land unsuitable for cultivation. There is a scope for double cropping to some extent in some parts of the district where the irrigation projects are in operation.

Table 3.1 Land utilization in Raigad district (2002-03)

Sr. No.	Land use category	Area '000' ha	Percentage to total geographical area
1.	Total geographical area	687	100.00
2.	Area under forest	149	21.69
3.	Land under non-agricultural use	52	7.57
4.	Barren land and land unsuitable for cultivation	104	15.14
5.	Permanent pastures and other grazing land	37	5.39
6.	Land under miscellaneous tree crops and grooves	31	4.51
7.	Cultivable waste land	56	8.15
8.	Current fallow	28	4.08
9.	Other fallow	24	3.49
10.	Net area sown	205	29.84
11.	Area sown more than once	31	15.12*
12.	Gross cropped area	236	115.12*
13.	Net irrigated area	12	5.85*

(* Figures are percentages to net area sown)

Source : Socio-economic Review and District Statistical Abstract of Raigad district (2003-04).

3.10 Cropping pattern

The cropping pattern of Raigad district is given in Table 3.2.

As shown in the Table 3.2, Rice is the principal crop of the district. The district occupies 1,41,700 hectares of land under rice which has 59.92 per cent share in gross cropped area. Rice cultivation is done on plains and low-lying areas, while nagli and other millets are grown on hilly slopes. Total area under cereals in the district was 161700 ha (68.37%) and pulses were grown on 13100 ha (5.54%). The major pulses grown in the Raigad district are tur in *kharif* season and mung, wal and gram in *Rabi* season.

The total area under foodgrain crops was 1,74,800 ha (73.91% of gross cropped area).

Table 3.2 Cropping pattern in Raigad district (2002-03)

Sr. No.	Crops	Area in '00' ha	Percentage to gross cropped area
1.	Cereals		
	a) Rice	1417	59.92
	b) Nagli	126	5.33
	c) Vari	74	3.12
	Total cereals	1617	68.37
2.	Pulses		
	a) Gram	24	1.02
	b) Tur	12	0.51
	c) Mung	11	0.47
	d) Udid	10	0.42
	e) Wal	66	2.79
	f) Kulith	1	0.04
	g) Matki	2	0.08
	h) Other pulses	5	0.21
	Total pulses	131	5.54
3.	Total foodgrains	1748	73.91
4.	Condiments and spices	10	0.42
5.	Fruits and vegetables	206	8.71
6.	Total food crops	1964	83.04
7.	Total oilseed crops	34	1.44
8.	Total non-food crops	367	15.52
9.	**Gross cropped area**	**2365**	**100**

Source : Socio-economic Review and District Statistical Abstract of Raigad district (2003-04).

3.11 Irrigation

The gross irrigated area of Raigad district was 14,441 ha in which the proportion of area irrigated by wells and other sources (including irrigation projects) was about 39.48 per cent and 60.52 per cent, respectively. The maximum proportion of gross irrigated area was under rice (55.40%) followed by pulses (6.54%) and fruits and vegetables (22.16%), whereas it was about 9 per cent under coconut and groundnut crops. The irrigated area was maximum of about 2392 ha in Karjat, followed by Khalapur tahsil (725 ha).

3.12 Livestock

Details of livestock population in the Raigad district are given in Table 3.3.

Table 3.3 Livestock population in Raigad district

(As per 1997 livestock census)

Sr. No.	Category of livestock	Number	Percentage to total livestock
1.	Cattle	451692	59.17
2.	Buffaloes	68573	8.98
3.	Buffalo bulls	78454	10.28
4.	Total bovine	598719	78.43
5.	Sheep	675	0.09
6.	Goat	159556	20.90
7.	Horse and Ponies	1201	0.16
8.	Other livestock	3271	0.43
9.	Total livestock	763422	100
10.	Poultry including other birds	1680401	--

Source : Socio-economic Review and District Statistical Abstract of Raigad District (2003-04).

As per the 1997 census, the total cattle population in the district was 4,51,692 out of which 15.16 per cent were milking cows. Total buffaloes were 68573, out of which 52.17 per cent were in milking stage. The sheep and goat population was 675 and 159556, respectively. Other livesock population in the district was 3271, thus total livestock population in the district was 763422.

3.13 Fisheries

Raigad district has a marine fishing coastline of about 240 km. There are 104 fishing villages and 39 fish landing centers. The total marine fish production was 38679 MT in 2003-04, which was worth of Rs. 8291.62 lakh. The utilization of fish for sun drying was about 15678 MT.

3.14 Transport and communication

A major state highway *viz.*, Mumbai-Goa highway (NH-4) and Konkan railway runs through the length of the district, which serves as a major means of transport. The total railway length passing through the district was 298.53 km at the end of 31st March, 2003 and road length was 5294.19 kms at the end of 31st march, 2004. The road length of this district is better than the other three districts of Konkan region. There are 24 railway stations in the district. There are 18 ports, all of which are seasonal in operation. There are 439 post offices and 1,29,164 telephones were in working condition in Raigad district. They serve as the important means of quick transport and communication.

3.15 Banking facilities

There were 199 branch offices of 92 banks in the district at the end of March, 2004. In addition to these, there were 101 branch offices of co-operative banks. About 135 villages and towns in the district have banking facilities. The loans advanced by these banks amounted to Rs. 99,564 lakhs and deposits with these banks amounted to Rs. 2,55,265 lakhs.

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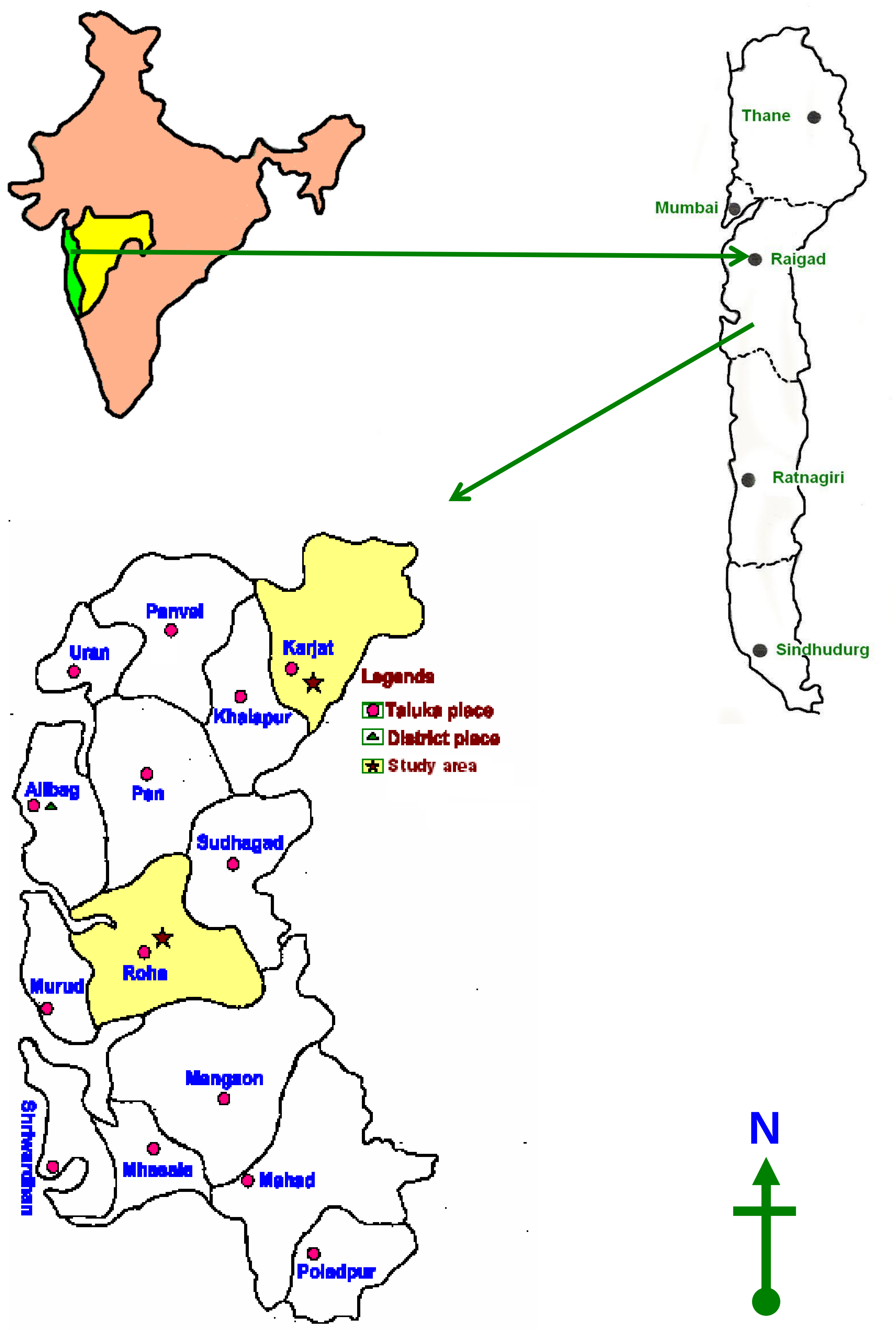
*Original not seen.

Fig. 1. Map of Raigad District Showing Area of Study



CHAPTER V

RESULTS AND DISCUSSION

The data collected from selected rice growers and reports of research station as per the methodology outlined in Chapter IV are analyzed. The results of the analysis are presented and discussed in this chapter. For the purpose of evaluating the objectives, the results of the study are presented under the following heads.

1. General information of sample farmers
2. Magnitude of input use gaps and yield gaps in rice
3. Factors affecting the yield gap in rice
4. Contribution of various factors to yield gap in rice
5. Economic comparison
6. Constraints responsible for yield gap in rice

5.1 General information of sample farmers

The general information of the sample farmers including age, education, family size and occupation is given in Table 5.1.

5.1.1 Age

It is observed from the Table 5.1 that, the average age of selected farmers in the study area was 42.55 years. This indicated that the average farmers were in middle age group.

5.1.2 Education

Education is another important factor influencing managerial and technical ability of farmers. The education status of head of the family was evaluated by giving zero point to illiterate farmer and one point for every standard attended by him. It is evident from Table 5.1 that, the overall education score was 7.96 which indicated that the farmers were educated up to eight standards.

Table 5.1 General information of farmers

Sr. No.	Particulars	N=60
1.	Age (years)	42.55
2.	Education score	7.96
3.	Occupation	
	a) Main (No. of farmers)	
	i) Farming	35 (58.33)
	ii) Service	9 (15.00)
	iii) Business	16 (26.67)
	Sub total	**60 (100.00)**
	b) Subsidiary (No. of farmers)	
	i) Farming	25 (41.67)
	ii) Business	7 (11.67)
	iii) Poultry	13 (21.66)
	iv) Dairy	9 (15.00)
	v) No subsidiary occupation	6 (10.00)
	Sub total	**60 (100.00)**
4.	Family	
	a) Male	2.42 (46.36)
	b) Female	2.23 (42.72)
	c) Children	0.57 (10.92)
	Total (a +b +c)	**5.22 (100.00)**
5.	Persons working on farm	
	a) Male	1.35 (53.36)
	b) Female	1.18 (46.64)
	Total (a + b)	**2.53 (100.00)**

(Figures in parentheses are percentages to total)

5.1.3 Occupation

It is observed from Table 5.1 that, most of the sample farmers were engaged in farming as their main occupation. Out of 60 farmers, 35 (58.33%) farmers were engaged in farming as their main occupation, while 9 (15.00%) and 16 (26.67%) farmers were having service and business as their main occupation, respectively. About subsidiary occupation, it was observed that nearly 90 per cent of the sample farmers were having farming, business, poultry or dairy as their subsidiary occupations.

5.1.4 Family size

Size of the family is the important factor influencing supply of farm labour, which also affects the income generating capacity of the farmer's family. It is revealed from the Table 5.1 that, the average size of family was 5.22 persons with 2.42 males (46.36%), 2.23 females (42.72%) and 0.57 children (10.92%) at an overall level.

5.1.5 Persons working on farm

Persons working on farm at an overall level were 2.53. Out of which, 53.36 per cent and 46.64 per cent were male and female members, respectively.

5.2 Land owned and its value

The average size of land owned by the sample farmers is presented in Table 5.2.

It could be seen from the Table 5.2 that, the average size of ownership holding was 1.76 hectares at an overall level. The proportion of *varkas* land in total ownership holding was highest (19.89%) followed by paddy (71.02%) and *Bagayat* land (9.09%). The *Bagayat* land was found to be negligible. The average size of ownership holding and operational holding was same. On the basis of quality, the land is classified as paddy land, *Bagayat* and *varkas* land. This quality of land is also reflected in the per hectare value of land. The total value of owned land was Rs. 71346.18. It was found that per hectare value of *Bagayat* land was higher followed by paddy and *varkas* lands. It was Rs. 43748.85 for paddy land, Rs. 61122.81 for *Bagayat* and about Rs. 19658.48 for *varkas* land.

Table 5.2 Land owned and its value

Sr. No.	Particulars	Overall farms
1.	Land owned (ha)	
	a) Paddy	1.25 (71.02)
	b) *Bagayat*	0.16 (9.09)
	c) *Varkas*	0.35 (19.89)
	Total	**1.76 (100.00)**
2.	Operational holding (ha)	1.76 (100.00)
3.	Total value of owned land (Rs.)	
	a) Paddy	54686.06
	b) *Bagayat*	9779.65
	c) *Varkas*	6880.47
	Total	**71346.18**
4.	Per hectare value of owned land (Rs.)	
	a) Paddy	43748.85
	b) *Bagayat*	61122.81
	c) *Varkas*	19658.48
	Total	**124530.14**

5.3 Land use pattern

The average land use pattern of selected farmers is shown in Table 5.3.

Table 5.3 Average land use pattern on sample farms

Sr. No.	Particulars	Area (ha)	Percentage
1.	Cultivated land		
	a) Irrigated	1.36	77.27
	b) Unirrigated	0.08	4.55
	Sub total	**1.44**	**81.82**
2.	Fallow land	0.04	2.27
3.	Land unsuitable for cultivation	0.28	15.91
	Grand total	**1.76**	**100.00**

It is seen from Table 5.3 that, average total land holding of sample farmers was 1.76 ha, which constituted 1.36 ha (77.27%) irrigated area and 0.08 ha unirrigated area (4.55%). Thus, the total cultivated area was observed to be 1.44 ha (81.82%). Remaining 0.04 ha area (2.27%) and 0.28 ha area (15.91%) was fallow land and land unsuitable for cultivation, respectively. The land use pattern indicated that, the farmers in the study area were having more irrigated area. This is because of the availability of canal irrigation facilities in study area.

5.4 Cropping pattern

The cropping pattern followed on sample farms and intensity of cropping is given in Table 5.4.

Table 5.4 Average cropping pattern on sample farms

Sr. No.	Particular	Area (ha)	Percentage
1.	*Kharif* season		
	a) Paddy	1.25	46.64
	b) Nagli	0.03	1.12
	Total *Kharif* crops (a + b)	1.28	47.76
2.	*Rabi*/Summer season		
	a) Summer paddy	1.15	42.91
	b) Pulses	0.04	1.49
	c) Vegetables	0.05	1.87
	Total *rabi*/ simmer crops(a + b + c)	1.24	46.27
3.	Perennials	0.16	5.97
4.	Gross cropped area	2.68	100.00
5.	Net sown area	1.44	--
6.	Cropping intensity (%)	186.11	--

The Table 5.4 revealed that the cropping pattern in study area is dominated by paddy crop. *Kharif* rice occupied 1.25 ha area (46.64%) whereas nagli crop was cultivated on an area of about 0.03 ha which accounted for only 1.12 per cent of the total cropped area. Thus, *Kharif* crops occupied total area of 1.28 ha (47.76%). While in summer season, because of canal irrigation facility, the crops like rice and vegetables were grown and the pulses were grown on residual moisture. The total area under *rabi*/summer season crops was 1.24 ha, out of which, area under summer rice was 1.15 ha. The perennial crops occupied about 5.97 per cent area which was grown on 0.16 ha. Thus, the gross cropped area and net sown area in the study area were found to be 2.68 ha and 1.44 ha, respectively with cropping intensity of 186.11 per cent. The analysis of cropping pattern of sample farmers indicated that, rice was the major crop grown by the farmers in *Kharif* as well as summer seasons.

5.5 Per farm investment in farm assets

The sample farmers were grouped unto three groups *viz*. small, medium and large on the basis of the land holding. The size group wise investment made by the farmers is discussed here.

The farm assets are very important from the point of view of obtaining credit as they indicate the economic position of the farmer. These assets generally include land, farm buildings, farm implements, machinery and livestock. Table 5.5 gives information about per farm investment in farm assets.

Table 5.5 Per farm investment in farm assets

(Value in Rs.)

Sr. No.	Assets	Farm size groups			
		Small (n=31)	**Medium (n=17)**	**Large (n=12)**	**Overall (n=60)**
1.	Land	10703.35 (28.22)	82949.04 (73.54)	211569.37 (78.13)	71346.18 (67.49)
2.	Farm buildings including cattle shed	13507.42 (35.61)	13958.53 (12.37)	16825.00 (6.21)	14298.75 (13.53)
3.	Implements and Machinery	2789.29 (7.35)	3638.41 (3.23)	22021.08 (8.13)	6876.23 (6.50)
4.	Livestock	10934.68 (28.82)	12252.35 (10.86)	20391.67 (7.53)	13199.42 (12.48)
	Total	**37934.74 (100.00)**	**112798.33 (100.00)**	**270807.12 (100.00)**	**105720.58 (100.00)**

(Figures in parentheses are percentages to total)

It could be seen from the Table 5.5 that average value of assets possessed by the farmers was Rs. 105720.58 at an overall level. It was about Rs. 37934.74, Rs. 112798.33 and Rs. 270807.12 in case of small, medium and large farms, respectively. The share of land in total value of assets was maximum followed by farm buildings including cattle shed, livestock and implements and machinery on overall sample farms. It was 67.49 per cent in land, 13.53 per cent in farm buildings including cattle shed, 6.50 per cent for implements and machinery and 12.48 per cent in livestock at an overall level. The share of land in total value of assets was found to be higher in case of medium and large farms but in case of small farm building including cattle shed contributed maximum to the total value of assets.

5.6 Mean level of input use and input gaps

The estimated mean levels of inputs used on demonstration plots and the sample farms as well as input use gaps are presented in Table 5.6.

Table 5.6 clearly shows that the higher quantities of different inputs except seed rate were used on demonstration plots as compared to those on the farmers' fields. It is seen from the Table 5.6 that the farmers did not spend on plant protection.

Table 5.6 displays the per cent gaps in input used as compared to demonstration plots. As shown in the table, the quantum of difference in the input use levels varied from one input to another. The estimated input gap was the highest for plant protection (100%) at an overall level. In case of human labour, the estimated gap was more for medium farms (15.94%) than that for large (13.39%) and small farms (1.14%) with 7.77 per cent at an overall level. The per cent gaps in expenditure on bullock and machine power were two times greater in large group (13.42%) as compared with small (4.77%) and medium farms (5.51%). It was about 6.71 per cent at an

Table 5.6 Mean levels of input use and input use gaps in rice production

(Per hectare)

Sr. No.	Variables	Demonstration plots	Farm size groups			
			Small (n=31)	Medium (n=17)	Large (n=12)	Overall (n=60)
1.	Human labour (days)	186.67	184.55 (1.14)	156.92 (15.94)	161.67 (13.39)	172.15 (7.77)
2.	Bullock and machine power (Rs.)	3082.95	2935.93 (4.77)	2913.14 (5.51)	2669.28 (13.42)	2876.14 (6.71)
3.	Seed rate (kg.)	45.00	60.86 (-35.24)	56.07 (-24.60)	64.48 (-43.29)	60.22 (-33.71)
4.	Manures (Rs.)	2114.07	1346.72 (36.29)	1374.89 (34.96)	1859.68 (12.03)	1457.29 (31.07)
5.	Plant nutrients (Rs.)					
	N	951.42	927.09 (2.56)	925.95 (2.68)	808.67 (15.00)	903.08 (5.08)
	P	774.97	317.94 (58.97)	340.07 (56.12)	339.97 (56.13)	328.62 (57.60)
	K	267.67	110.00 (58.90)	169.08 (36.83)	131.45 (50.89)	131.03 (51.05)
6.	Plant protection (Rs.)	151.97	--	--	--	--

(Figures in parentheses are per cent gap in the input use compared to the demonstration plots)

overall level. The gaps in expenditure of nitrogenous fertilizers were found to be very less in case of small (2.56%) and medium farms (2.68%) with 5.08 per cent at an overall level, while it was 15 per cent on large farms, which was quite higher. In case of expenditure on P and K nutrients, the gaps were worked out to the tune of 57.60 per cent and 51.05 per cent, respectively at an overall level. It was found that the gap in manure cost at overall level was 31.07 per cent. As revealed by the Table 5.6, the actual farms were found to use excess seed rate which lead to negative gap. This is because broadcasting method of sowing is generally followed by the farmers, which requires higher quantity of seed.

The analysis revealed a considerable gap in expenditure on manures and plant nutrients, especially P and K nutrients, between the demonstration plots and the sample farms. These gaps have got to be minimized, if potential farm yield has to be achieved. Medium farms were observed to have lower gaps in plant nutrients like N, P and K as compared to small and large farms which led to higher yield of rice realized on medium farms.

5.7 Magnitude of yield gaps in rice

The present study concentrated on the analysis of yield gap in rice irrespective of specific varieties of rice. Yield gaps in rice production were estimated in case of small, medium and large farms.

5.7.1 Rice yield under different farm situations

Per hectare yield of rice realized under different farm situations is presented in Table 5.7.

Table 5.7 Realized rice yield under different farm situations

Sr. No.	Particulars	Yield (q/ha)
1	Potential yield (Research station yield)	46.68
2	Potential farm yield (Demonstration plot's yield)	44.57
3	Actual yield	
	a) Small	30.99
	b) Medium	31.84
	c) Large	31.26
	d) Overall	31.29

It is observed from the Table 5.7 that, the potential yield of rice (yield realized on research station farms) was found to be 46.68 quintals per hectare whereas the potential farm yield of rice (yield realized at demonstration plots) was found to be 44.57 quintals per hectare. The average yield of rice realized by the sample farmers was 31.29 quintals per hectare. Per hectare yield realized by the sample farmers was observed to be 30.99 quintals, 31.84 quintals and 31.26 quintals on small, medium and large farms, respectively, which indicated that there is slight difference in the yield of rice obtained at different sized farms. It is revealed from the Table 5.7 that there was a wide gap between the potential yield and the actual yield of rice one hand and between the potential farm yield and the actual yield on the other.

5.7.2 Estimation of yield gaps in rice

The estimated yield gaps in rice production are depicted in the Table 5.8.

It is seen from the Table 5.8 that there existed a wide gap of 2.11 quintals per hectare (4.52%) between the potential yield and the actual farm yield of rice. The yield gap between the potential farm yield and the actual farm yield were found to be 13.58 quintals, 12.73 quintals and 13.31 quintals per hectare on small, medium and large farms, respectively with 13.28 quintals per hectare on overall farms. This gap is termed as 'extension gap' and it could be minimized through efficient extension activities. The results clearly indicated that total yield gap was observed in rice production was 15.39 quintals per hectare at an overall level. The magnitude of the total yield gaps were observed to be 15.69 quintals, 14.84 quintals and 15.42 quintals per hectare on small, medium and large farms, respectively.

Table 5.8 Estimated yield gaps in rice

Sr. No.	Particulars	Yield gaps (q/ha)
1.	Yield gap-I (Potential yield-Potential farm yield)	2.11 (4.52)
2.	Yield gap-II (Potential farm yield -Actual yield)	
	a) Small group	13.58 (30.47)
	b) Medium group	12.73 (28.56)
	c) Large group	13.31 (29.86)
	d) Overall	13.28 (29.80)
3.	Total yield gap	
	a) Small group	15.69 (33.61)
	b) Medium group	14.84 (31.79)
	c)Large group	15.42 (33.03)
	d) Overall	15.39 (32.97)

(Figures in parentheses are the respective percentages of yield gap)

3.7.3 Estimation of yield gap indices in rice

Various yield gap indices in rice were worked out and the same are presented in the Table 5.9. As indicated by Table 5.9, the index of yield gap was highest on small farms, followed by large and medium farms. It was 33.61 per cent, 31.79 per cent and 33.03 per cent on small, medium and large farms, respectively with 32.97 per cent at an overall level, which indicated the extent of unrealized yield potential.

Table 5.9 Estimated yield gap indices in rice

(Figures in per cent)

Sr. No.	Particulars	Yield gap indices			
		Small	Medium	Large	Overall
1.	Index of yield gap	33.61	31.79	33.03	32.97
2.	Index of realized potential yield	66.39	68.82	66.97	67.03
3.	Index of realized potential farm yield	69.53	71.44	70.14	70.20

From the results, it was found that the index of realized potential farm yield (70.20%) was higher than the index of realized potential yield (67.03%) at overall level. This indicated that, the farmers were successful in exploiting potential farm yield of rice to the extent of 69.53 per cent, 71.44 per cent and 70.14 per cent on small, medium and large farms, respectively. The analysis indicated that the farmers in general, had succeeded in exploiting about 70.20 per cent of the potential farm yield of rice. This revealed the possibility of increasing rice output at least by one-fourth of the present level, if the technology know-how available to the farmers was adopted fully and properly.

Primary emphasis was given on yield gap-II because this alone was expected to be emendable for policy influence. Physical and environmental differences between the research farms and average farms responsible for yield gap-I were difficult to change through policy measures. Therefore, it is not realistic to compare the potential yield with the actual farm yield.

5.8 Factors affecting the yield gap in rice

The crop productivity primarily depends on the extent of resources used and total crop management. It is observed that the recommended package of practices was not followed by most of the farmers which leads to existence of a wide gap between the potential farm yield and actual farm yield. In order to narrow down the yield gap in rice, it is necessary to find out the factors affecting the yield gap.

The estimated parameters of production functions of the sample farms in respect of elasticities of yield gap, standard errors, regression coefficients, their significance and the coefficients of multiple determination (R^2) are shown in Table 5.10.

5.8.1 Yield gap in rice on small farms

It is noted from the Table 5.10 that the estimated R^2 of the yield gap functions was 0.91 implying that the selected independent variables have explained appreciable variation in the yield gap in rice production. Therefore, this specified model was considered as a good fit to analyze the impact of selected variables on yield gap.

The selected independent variables have explained 91 per cent variation in the yield gap in the production of rice on the small farms. The regression coefficient of phosphorus gap was positive and significant at 10 per cent probability level. This indicated that, one unit decrease in the gap of phosphorus will minimize the yield gap in rice by 4.99 quintals per hectare. The regression coefficients of human labour gap and gap in bullock and machine power were negative and significant at 5 per cent probability level. These negative and significant coefficients indicated that, one unit increase in both the human labour and bullock and machine power will minimize the yield gap by 0.01 quintals per hectare. Whereas

Table 5.10 Results of estimated yield gap function for rice on sample farms

Sr. No.	Particulars	Regression coefficients			
		Small (n=31)	Medium (n=17)	Large (n=12)	Overall (n=60)
1.	Constant	-21.0205	8.1354	-2.6896	-1.6359
2.	Human labour gap (days)	-0.0134 ** (0.0063)	-0.011 (0.0071)	-0.012 (0.0005)	0.0724*** (0.0162)
3.	Bullock and machine power gap (Rs.)	-0.0108** (0.0046)	0.0818*** (0.0069)	-0.0116*** (0.002)	0.1130*** (0.0217)
4.	Seed rate gap (kgs)	0.0038 (0.0298)	0.0045 (0.0042)	0.0016 (0.0012)	0.0027 (0.0158)
5.	Manure gap (Rs.)	-0.0241*** (0.0083)	3.1961*** (0.5258)	-2.0489*** (0.3053)	0.2651*** (0.0292)
6.	Nitrogen gap (Rs.)	-0.0072 (0.0081)	-0.0492*** (0.0076)	2.3305*** (0.0893)	-0.1233*** (0.0261)
7.	Phosphorus gap (Rs.)	4.9919* (2.7903)	-4.4675*** (0.3538)	1.1566 (0.9548)	-0.6483*** (0.2027)
8.	Potassium gap (Rs.)	-1.3264 (2.7877)	0.0514 (0.6333)	-0.2601 (0.2337)	1.2886*** (0.0856)
	R^2	0.91**	0.94**	0.98**	0.89**
	F value	75.19	707.06	933.85	139.75

(Figures in parentheses are standard errors of the regression coefficients.)

*** Significant at 1 per cent probability level.

** Significant at 5 per cent probability level.

* Significant at 10 per cent probability level

one unit increases in the gap of manure will minimize the yield gap in rice by 0.02 quintals per hectare. The gap in expenditure on N and K fertilizers and seed rate were found to have non-significant association with the yield gap between the demonstration farm yield and actual farm yield of rice. The positive coefficients indicated the lower use of the resources while the negative regression coefficients indicated that excess use of the resources needs to be reduced. The F value was significant at 5 per cent probability level, thereby indicating the overall significance of the estimated yield gap function.

5.8.2 Yield gap in rice on medium farms

The results of the estimated production function analysis indicated that the selected independent variables have jointly explained 94 per cent variation in the yield gap in rice on the medium farms. The regression coefficients of expenditure on bullock and machine power and manure cost were positively and significantly associated with the yield gap in rice. The yield gap will be minimized by 0.08 quintals per hectare and 3.20 quintals per hectare with one unit decrease in the gap of expenditure on bullock and machine power and manure cost, respectively, implying the one unit increase in the use of these two variables. The association of the nitrogen and phosphorus gaps with the yield gap in the rice was found to be negative and significant at 1 per cent probability level which indicated that the yield gap could be minimized by 0.05 quintals and 4.47 quintals per hectare, respectively with one unit increase in the gap of both the variables.

5.8.3 Yield gap in rice on large farms

The proportion of total variation explained jointly by the selected independent variables in the regression model of rice was 98 per cent.

The yield gap in rice was found to be positively associated with the gaps in nitrogen which was significant at 1 per cent probability level, which indicated that one unit decrease in the gap of N would minimize the yield gap by 2.33 quintals per hectare. The regression coefficients of gaps in bullock and machine power and manures were estimated to be negative and significant at 1 per cent probability level, which indicated that one unit increase in the gap of these variables would minimize the yield gap by 0.01 quintal and 2.05 quintals per hectare, respectively. This implied that there is a scope to increase the use of nitrogenous fertilizers for minimizing the yield gap. The variables like seed rate and phosphorus were found to have positive association with yield gap but they turned out to be non-significant. Similar non-significant and negative association was found between the independent variables like human labour potassium gap and dependent variable of yield gap in rice.

The F value which indicates the overall significance of the production function being significant at 5 per cent probability level implies that the selected variables have explained the appreciable variation in the dependent variable (yield gap).

5.8.3 Yield gap in rice on overall farms

On overall farms, the yield gap in rice was observed mainly due to lower use of human labour, bullock and machine power, manures and potassic fertilizer. The yield gap in rice at an overall level will be minimized by 0.07 quintal, 0.11 quintal, 0.26 quintal and 1.28 quintals per hectare with one unit increase in the use of the inputs like human labour, bullock and machine power, manures and potassic fertilizers, respectively. The negative and significant association was found between the input gaps like human labour, nitrogen, phosphorus and the yield gap in rice. This indicated that one unit decrease in the use of nitrogenous and phosphoric fertilizers will minimize the yield gap in rice by 0.12 quintal and 0.64 quintal per hectare. The selected independent input variables have jointly explained about 89 per cent of variation in yield gap in rice.

From the above discussion, it is apparent that the gap between the recommended level of all key inputs for demonstration farms and actual input use levels on sample farms was found to be a major reason for wide difference in yield between the potential farm yield and actual farm yield. These findings were also confirmed with the results of 'Reddy *et al.*' (1996). Therefore, it can be inferred from the estimates of yield gap functions that the gap between the potential farm yield and actual farm yield could be minimized by the adoption of recommended levels of key inputs for enhancing yields under actual farm situations.

5.9 Contribution of various factors to yield gap

With decomposition equation presented in Chapter IV using the values of production parameters shown in Appendix I and the geometric mean levels of inputs and output levels shown in Appendix II, the contribution of input use gaps to yield gap in rice was estimated. The results of the decomposition analysis are presented in Table 5.11.

Table 5.11 revealed that the total productivity difference in rice between the potential farm yield and the actual yield on sample farms was estimated to be 37.28 per cent, 34.46 per cent and 29.82 per cent, on small, medium and large farms, respectively with 31.43 per cent on overall farms.

The yield gap was decomposed into inappropriate technique of production and difference in input levels. Of this yield gap, 0.15 per cent contribution was due to inappropriate techniques of production at small farms. In case of medium and large farms, the contribution of inappropriate techniques of production was observed to be negative. This is because the rice varieties grown in study area were high yielding varieties and there was awareness among the farmers regarding its cultivation practices.

Table 5.11 Contribution of various factors to yield gap

Sr. No.	Factors	Percentage contribution			
		Small (n=31)	Medium (n=17)	Large (n=12)	Overall (n=60)
1.	Inappropriate techniques of production	0.15	-0.13	-2.91	-0.52
2.	Sub-optimal use of inputs				
	a) Human labour	0.10	1.17	0.92	0.57
	b) Bullock and machine power	2.17	2.87	6.25	3.57
	c) Seed	0.08	0.06	0.09	0.07
	d) Manures	11.52	11.07	3.91	5.92
	e) N	0.04	0.05	0.56	0.14
	f) P	16.98	16.05	15.98	16.52
	g) K	6.24	3.32	5.02	5.16
	Total change due to inputs	37.13	34.59	32.73	31.95
3.	**Total change due to all factors**	**37.28**	**34.46**	**29.82**	**31.43**

The contribution of input use gaps to yield gap was worked out to 37.13 per cent on small farms followed by medium farms (34.59 %) and large farms (32.73%) with 31.95 per cent at an overall level. Among the inputs, phosphorus nutrient contributed the most to the yield gap in rice at an overall level followed by manures and potassium. The contribution of phosphorus was 16.52 per cent in rice, which indicated that a large portion of the potential farm productivity in rice could be exploited by using recommended levels of phosphoric fertilizers on the sample farms. Human labour, seed rate and nitrogen contributed very less to yield gap in rice. It could be inferred from the foregoing analysis that a better guidance about the recommended levels of all key inputs especially phosphorus and potassium nutrients would help the farmers to realize more yield than they do now. The analysis thus reinforced the conviction that yield gap is completely attributable to the sub-optimal input use on the sample farm.

5.10 Cost and returns

Per hectare paid out cost incurred and returns realized on the demonstration plots and the overall farms is given in Table 5.12.

The per hectare expenses on inputs were estimated by considering paid out costs incurred on seed, human labour, bullock and machine power, manures and fertilizers, plant protection chemicals and also interest on working capital. The total returns were estimated taking into consideration the value of grain (main) as well as straw (byproduct) yield. The returns over working expenses were also worked out. It is observed from the Table 5.12 that per hectare working cost was higher on demonstration plots (Rs. 21763.21) as compared to the working cost on overall farms which was found to be Rs. 18332.90. It was about Rs. 18509.58, Rs. 17888.86 and Rs. 18505.57 on small, medium and large farms, respectively. Per hectare total returns were worked out to Rs. 29249.22 and Rs. 20517.79 on the demonstration farms and overall actual farms, respectively. It is found that higher returns were obtained on medium farms (Rs. 20972.19) followed by large farms (Rs. 20556.01) and small farms (Rs. 20246.95). Per hectare returns over working expenses were estimated to be Rs. 7486.01 on the demonstration plots which was much higher than that obtained on the overall farmers' field (Rs. 2184.89) at an over level. It was about Rs. 1737.37, Rs. 3083.33 and Rs. 2050.44 on small, medium and large farms. Small farms were found to obtain comparatively lower per hectare returns over working expenses than medium and large farms.

Table 5.12 Per hectare paid out cost and returns from rice cultivation

(Amount in Rs.)

Sr. No.	Particulars	Demonstr-ation plots	Farm size groups			
			Small (n=31)	Medium (n=17)	Large (n=12)	Overall (n=60)
1.	Seed	585.00	669.21	560.28	735.18	651.54
2.	Human labour	12506.89	11073	10513.64	10831.89	10866.29
3.	Bullock and machine power	3082.95	2935.93	2913.14	2669.28	2876.14
4.	Manures	2114.07	1346.72	1374.89	1859.68	1457.29
5.	Fertilizers - N	951.42	927.09	925.95	808.67	903.08
	P	774.97	317.94	340.07	339.97	328.62
	K	267.67	110.00	169.08	131.45	131.03
6.	Plant protection	151.97	--	--	--	--
7.	Interest on working capital	1328.27	1129.69	1091.81	1129.45	1118.91
	Total working expenses	**21763.21**	**18509.58**	**17888.86**	**18505.57**	**18332.90**
8.	Output value					
	a) Main product	24513.21	17044.50	17512.00	17193.00	17209.5
	b) By product	4736.72	3202.45	3460.19	3363.01	3308.29
	Total output value	**29249.22**	**20246.95**	**20972.19**	**20556.01**	**20517.79**
9.	Returns over working expenses	7486.01	1737.37	3083.33	2050.44	2184.89

Prices considered were Rs. 550/quintal for grain yield and Rs. 100/quintal for straw yield.

5.11 Economic comparison

The economic comparison is made on the basis of farmers' paid out costs and returns with cost and returns of the demonstration plots. The increased value of output and increased cost on the higher level of inputs used on the demonstration farms are also estimated and shown in the Table 5.13.

Table 5.13 Economic comparison of farmers' yield with the potential farm yield

Particulars	Farm size groups			
	Small (n=31)	**Medium (n=17)**	**Large (n=12)**	**Overall (n=60)**
Yield				
a) Grain (q/ha)	30.99	31.84	31.26	31.29
b) Straw (q/ha)	32.02	34.60	33.63	33.08
Yield gap				
a) Grain (q/ha)	13.58	12.73	13.31	13.28
b) Straw (q/ha)	15.34	12.76	13.73	14.28
Increased value of output (Rs.)	9002.27	8227.03	8693.21	8731.43
Input cost (Rs.)	18509.58	17888.86	18505.57	18332.90
Increased cost on the demonstration plots (Rs.)	3253.63	3874.35	3257.64	3430.78
Increased net benefit from the demonstrations (Rs.)	5748.64	4402.68	5435.57	5301.12
Benefit cost ratio of increased inputs	2.76	2.12	2.67	2.55

Demonstration farms' yield: Grain - 44.57 q/ha and Straw - 47.36 q/ha

It can be seen from the Table 5.13 that per hectare additional grain (main) and straw (byproduct) yield realized on the demonstration farms was 13.28 quintals and 14.28 quintals when compared with overall farmers' yields. The increased value of output on the demonstration farms were Rs. 9002.27, Rs. 8227.03, Rs. 8693.21 and Rs. 8731.43 over small, medium, large and overall farms, whereas the increased cost on the demonstration plots was Rs. 3253.63, Rs. 3874.35, Rs. 3257.64 and Rs. 3430.78 over small, medium, large and overall actual farms. Thus, the difference between the increased value of output and the increased costs on the demonstration farms was estimated to be Rs. 5748.64, Rs. 4402.68, and Rs. 5435.57 and Rs. 5301.12 in case of small, medium, large and overall actual farms. These indicated the increased net returns from the demonstrations in respect of farm size groups. The benefit cost ratios of increased inputs on the demonstration plots came to 2.76, 2.12, 2.67 and 2.55 over the input levels of the small, medium, large and overall farms. It clearly indicated that the farmers can increase their returns by adopting the input use practices which are followed on the demonstration plots.

5.12 Constraints responsible for yield gap

Optimum quantity and timely use of inputs according to the recommendations in the cultivation of any crop holds large importance in minimizing the yield gap. This important knowledge is, however, not fully exploited by the farmers in the study area. Therefore, the constraints operating at farm level has been identified and analyzed. Such an analysis would help to minimize the constraints responsible for low yield on actual farms. In the present study, an attempt has been made to analyze the constraints preventing the farmers from realizing the potential farm yield in rice crop. The perceived constraints for attaining higher yield in *Kharif* rice are presented in the Table 5.14.

Table 5.14 Perceived constraints on attaining higher yields in rice

(Figures in per cent)

Sr. No.	Particulars	Farm size groups			
		Small (n=31)	Medium (n=17)	Large (n=12)	Overall (n=60)
1.	Constraints regarding rainfall				
	a) Excess	80.64	88.23	75.00	81.66
	b) Abnormal distribution	87.10	88.24	91.67	88.34
2.	Constraints regarding HYV seed				
	a) High cost	90.55	70.58	58.33	79.98
	b) Inadequate supply	63.33	72.58	75.53	68.39
	c) Non-availability in time	62.58	55.18	65.67	61.10
3.	Labour constraints				
	a) Inadequate	48.39	35.29	33.33	41.67
	b) High wage rates	83.55	80.50	72.63	80.50
	c) Non-availability at peak period	32.26	58.82	58.33	45.00
4.	Fertilizer constraints				
	a) High cost	78.00	88.00	80.00	83.23
	b) Inadequate supply	35.48	23.53	33.33	31.66
	c) Untimely supply	67.74	52.94	50.00	60.00
5.	Credit constraints				
	a) Inadequate owned capital	72.00	68.00	33.33	63.13
	b) Complicated loan procedure	64.52	82.35	50.00	66.67
	c) Untimely supply	35.48	47.06	66.67	50.00
	d) Inadequate supply	32.26	70.59	50.00	46.67
	e) High interest rate	83.87	76.47	75.00	80.00
6.	Lack of technical know-how	45.16	11.76	8.33	28.33
7.	Lack of communication facilities	19.35	17.65	16.67	18.33
8.	Insecticides/pesticides				
	a) High cost	100	92.00	75.00	92.73
	b) Non-availability in a village	41.94	---	---	41.94
	c) Inadequate supply	---	23.53	50.00	16.67
9.	Low price to farm produce	54.83	88.24	91.67	71.66
10.	Small sized farms	93.55	29.41	25.00	61.67

It is seen from the Table 5.14 that 81.66 per cent and 88.34 per cent farmers, reported excess rainfall and abnormal distribution of rainfall in last *kharif* season which was a major constraint for low yield of rice, respectively at an overall level. About the constraints regarding seed material, like high cost of seed, inadequate supply and non-availability in time were reported by 79.98 per cent, 68.39 per cent and 61.10 per cent farmers, respectively at an overall level. About 93.55 per cent small farmers quoted the constraint of high cost of seed. High wage rate as a constraint responsible for increased cost of cultivation was expressed by 83.55 per cent small farmers, 80.50 per cent medium and 72.63 per cent large farmers with 80.50 per cent at an overall level. Other labour constraints like inadequate supply of labour and scarcity of labour at peak period were reported by 41.67 per cent and 45 per cent sample farmers, respectively at an overall level.

About chemical fertilizers' problem like high cost, inadequate supply and untimely supply were expressed by 81.23 per cent, 31.66 per cent and 60 per cent farmers, respectively at an overall level. In case of credit, inadequate owned capital, complicated loan procedure, and high interest rates were the difficulties reported by 72.16 per cent, 64.52 per cent, 83.87 per cent small farmers. Medium farmers faced major constraints like complicated loan procedure (82.35%) followed by high interest rates (76.47%) and inadequate supply of credit for agricultural purpose (70.59%). While about 75 per cent and 66.67 per cent of large farmers quoted high interest rate and untimely supply of loan respectively, as a major credit constraints. At an overall level, about 80 per cent sample farmers reported high interest rates as a major credit constraint. Regarding the insecticides use, the problems like high cost, non-availability in a village and inadequate supply were reported by

92.73 per cent, 41.94 per cent and 16.67 per cent farmers, respectively at an overall level. It was found that high cost of pesticides, non availability in a village and inadequate supply of pesticides were major constraints opined by 92.73 per cent, 41.94 per cent and 16.67 per cent of the sample farmers respectively, at an overall level. These led to a substantial gap in the use of plant protection on the sample farms which were found to be a major cause for yield gap in rice.

Lack of technical know-how as one of the constraints in attaining higher yields was expressed by 45.16 per cent small farmers, 11.76 per cent medium and 8.33 per cent large farmers with 28.33 per cent sample farmers at an overall level. Other constraints like the low price to farm produce and small sized and fragmented farms and low price to farm produce as constraints reported by 71.66 per cent and 61.67 per cent of the farmers, respectively at an overall level. Small sized and fragmented farms as a constraint responsible for yield gap in rice was primarily quoted by 93.55 per cent small, 29.41 per cent medium and 25 per cent large farmers.

Table 5.1 General information of farmers

Sr. No.	Particulars	N=60
1.	Age (years)	42.55
2.	Education score	7.96
3.	Occupation	
	a) Main (No. of farmers)	
	i) Farming	35 (55.33)
	ii) Service	9 (15.00)
	iii) Business	16 (26.67)
	Total	**60 (100.00)**
	b) Subsidiary	
	i) Farming	25 (41.67)
	ii) Business	7 (11.67)
	iii) Poultry	13 (21.66)
	iv) Dairy	9 (15.00)
	v) No. of subsidiary occupation	6 (10.00)
	Total	**60 (100.00)**
4.	Family	
	a) Male	2.42 (46.36)
	b) Female	2.23 (42.72)
	c) Children	0.57 (10.92)
	Total (a+b+c)	**5.22 (100.00)**
5.	Persons working on farm	
	a) Male	1.35 (53.36)
	b) Female	1.18 (46.64)
	Total (a+b)	**2.53 (100.00)**

(Figures in parantheses are percentages to total)

Table 5.2 Land owned and its value

Sr. No.	Particulars	Overall farms
1.	Land owned (ha)	
	a) Paddy	1.25 (45.29)
	b) Bagayat	0.16 (5.80)
	c) Varkas	1.35 (48.91)
	Total	**2.76** **(100.00)**
2.	Operational holding (ha)	2.76 (100.00)
3.	Total value of owned land (Rs.)	
	a) Paddy	54.686.06
	b) Bagayat	9779.65
	c) Varkas	23652.33
	Total	**88118.04**
4.	Per hectare value of owned land (Rs.)	
	a) Paddy	52313.01
	b) Bagayat	62316.11
	c) Varkas	19658.48
	Total	**132287.60**

Table 5.3 Average land use pattern on sample farms

Sr. No.	Particulars	Area (ha)	Percentage
1.	Cultivated land		
	a) Irrigated	1.30	47.10
	b) Unirrigated	0.15	5.53
	Sub-Total	**1.45**	**52.53**
2.	Fallow	0.04	1.45
3.	Land unsuitable for cultivation	1.27	46.02
	Grand Total	**2.76**	**100.00**

Table 5.4 Average cropping pattern on sample farms

Sr. No.	Particular	Area (ha)	Percentage
1.	*Kharif* season		
	a) Paddy	1.25	48.45
	b) Nagli	0.03	1.16
	Total Kharif crops (a + b)	1.28	49.61
2.	Rabi/Summer season		
	a) Summer paddy	0.90	34.88
	b) Pulses	0.15	5.81
	c) Vegetables	1.13	44.19
3.	Perennials	0.16	6.20
4.	Total cropped area	2.58	100.00
5.	Net cropped area	1.45	--
6.	Cropping intensity (%)	179.17	--

Table 5.5 Per farm investment in farm assets

Sr. No.	Assets	Value (Rs.)	Percentage to total
1.	Land	88118.04	73.83
2.	Farm buildings including	10161.53	8.51
3.	Implements and Machinery	6876.23	5.76
4.	Livestock	14199.42	11.90
	Total	**119355.22**	**100.00**

Table 5.6 Mean levels of input use and input use gaps in rice production

(Per hectare)

Sr. No.	Variables	Demonstration plots	Field situation			
			Jaya	Karjat-3	Ratna	Overall
1.	Human labour (days)	186.67	165.38 (11.41)	155.84 (16.52)	163.88 (12.21)	162.56 (12.92)
2.	Bullock power (Rs.)	3082.95	2932.59 (4.8)	2801.72 (9.12)	2819.13 (8.56)	2853.34 (7.45)
3.	Seed (kgs.)	45.00	61.31	56.16	59.43	59.32
4.	Manures (Rs.)	2114.067	1625.66 (23.10)	1635.01 (22.66)	1607.50 (23.96)	1619.86 (23.38)
5.	Plant nutrients (Rs.)					
	N	951.4204	936.44 (1.57)	867.32 (8.84)	880.99 (7.40)	895.09 (5.92)
	P	774.9707	305.93 (60.52)	244.48 (68.45)	242.51 (68.71)	264.29 (65.9)
	K	267.67	129.89 (51.47)	133.85 (49.99)	98.01 (63.38)	113.25 (57.69)
6.	Plant protection (Rs.)	151.97	--	--	--	--

(Figures in parentheses are per cent gap in the input use compared to the demonstration plots)

Table 5.7 Realised rice yield under different situations

(Figures in q/ha)

Sr. No.	Particulars	Yield
1	Potential yield (Research station yield)	146.68
2	Potential farm yield (Demonstration plots yield)	44.57
3	Actual yield	
	a) Jaya	32.63
	b) Karjat-3	30.46
	c) Ratna	29.73
	d) Overall	30.92

Table 5.8 Estimated yield gaps in rice

(quintals/hectare)

Sr. No.	Particulars	Yield gaps
1.	Yield gap-I (Potential yield-potential farm yield)	2.11 (4.52)
2.	Yield gap-II Potential farm yield actual yield)	
	a) Jaya	11.94 (126.78)
	b) Karjat-3	14.11 (31.66)
	c) Ratna	14.84 (33.30)
	d) Overall	13.65 (30.63)
3.	Total yield gap	
	a) Jaya	14.05 (30.10)
	b) Karjat-3	16.22 (34.75)
	c) Ratna	16.95 (36.31)
	d) Overall	15.76 (33.76)

(Figures in parentheses are the respective percentages)

Table 5.9 Estimated yield gap indices in rice

(Figures in percentages)

Sr. No.	Particulars	Yield gap indices			
		Jaya	Karjat-3	Ratna	Overall
1.	Index of yield gap	30.10	34.75	36.31	33.76
2.	Index of realized potential yield	69.90	65.25	63.69	66.62
3.	Index of realized potential farm yield	73.21	68.34	66.70	73.86

Table 5.10 Results of estimated yield gap function for rice on sample farms

Sr. No.	Particulars	Yield gap indices			
		Jaya (N=37)	Karjat-3 (N=25)	Ratna (N=48)	Overall (N=110)
1.	Constant	-9.5183	-44.1051	4.8076	-4.2926
2.	Human labour gap (days)	-0.3356*** (0.0671)	-0.0159 (0.0138)	-0.1273 (0.2081)	-0.061** (0.0302)
3.	Bullock labour gap (Rs.)	0.0365 (0.517)	0.0735*** (0.0160)	0.0101 (0.0309)	0.0699** (0.0279)
4.	Seed rate gap (kgs)	-0.0421 (0.0595)	0.0128 (0.0202)	0.025 (0.026)	0.0062 (0.0290)
5.	Manure gap (Rs.)	-0.2306** (0.1039)	0.2477*** (0.0180)	0.2999*** (0.0329)	0.1710*** (0.033)
6.	Nitrogen (Rs.)	0.1914** (0.906)	22.3833 (46.356)	0.0562 (0.1082)	0.0308 (0.0369)
7.	Phosphorus gap (Rs.)	-0.0334 (0.1095)	-16.0798 (34.409)	-1.0624 (1.0429)	0.02132 (0.0767)
8.	Potassium gap (Rs.)	2.7516*** (0.3903)	-0.2175 (0.8326)	0.8666*** (0.2593)	1.0708*** (0.1420)
	R^2	0.8134	0.9452	0.8110	0.6796
	F value	18.0639	41.86	24.52	20.90

*** Significant at 1 per cent probability level.

** Significant at 5 per cent probability level.

Table 5.11 Contribution of various factors to yield gap

Sr. No.	Factors	Percentage contribution			
		Jaya	Karjat-3	Ratna	Overall
1.	Differences in cultural practices	-4.01	-0.29	0.8	-3.02
2.	Sub-optimal use of inputes				
	a) Human labour	0.91	1.28	1.23	1.089
	b) Bullock and machine Power	2.18	4.16	36.68	3.29
	c) Seed	0.08	0.06	0.07	0.07
	d) Manures	6.96	6.58	7.36	7.05
	e) N	0.04	0.12	0.11	0.09
	f) P	21.56	22.278	22.75	22.33
	g) K	5.46	4.88	7.35	6.35
	Total due to inputs	37.19	38.58	42.55	40.13
3.	Total due to all factors	33.18	38.59	41.75	37.11
4.	Total changes in measured output	32.14	38.48	41.22	37.39

Table 5.12 Per hectare cost and returns of rice

Sr. No.	Particulars	Amount (Rs.)	
		Decomposition plots	**Actual farms**
1.	Seed	585.00	729.36
2.	Human labour	12506.89	10891.34
3.	Bullock power	3082.95	285.34
4.	Manures	2114.07	1619.86
5.	Fertilizers - N	951.42	896.53
	P	774.97	264.29
	K	151.97	116.88
6.	Plant protection	1328.27	--
7.	Interest on working capital	1328.27	1129.15
8.	Total working expenses	21763.21	18500.75
9.	Output value		
	a) Main product	28970.50	19518.83
	b) By product	473.72	3476.96
	Total	**33706.22**	**22995.79**
10.	Returns over working expenses	11943.01	4495.04

Table 5.13 Economic comparison of farmers' yield with the potential farm yield

Particulars	Overall farms
Yield	
a) Grain (q/ha)	30.87
b) Straw (q/ha)	34.77
Yield gap	
a) Grain (q/ha)	13.70
b) Straw (q/ha)	12.59
Increased value of output (Rs.)	10710.43
Input cost (Rs.)	
a) Farmers' cost	18500.75
b) Increased cost on the demonstration plots	3262.46
Increased net benefit from the demonstrations	7447.97
Benefit cost ratio of increased inputs	3.11

Demonstration farms' yield : Grain yield = 44.57 q/ha
Straw yield = 47.36 q/ha

Table 5.14 Perceived constraints on attaining higher yields in rice

(Figures in per cent)

Sr. No.	Particulars	Sample farmers (N=60)
1.	Constraints regarding rainfall	
	a) Excess	100
	b) Abnormal distribution	88.34
2.	Constraints regarding HYV seed	
	a) High cost	94.67
	b) Inadequate supply	2.00
	c) Non-availability in time	31.67
3.	Labour constraints	
	a) Inadequate	41.67
	b) High wage rates	96.67
	c) Non-availability at peak	45.00
4.	Fertilizer constraints	
	a) High cost	100
	b) Inadequate supply	31.66
	c) Untimely supply	60.00
5.	Credit constraints	
	a) Inadequate owned capital	41.67
	b) Complicated loan procedure	66.67
	c) Untimely supply	50.00
	d) Inadequate supply	46.67
	e) High interest rate	80.00
6.	Lack of technical know-how	13.33
7.	Lack of communication facilities	18.33
8.	Insecticides/pesticides	
	a) High cost	100
	b) Non-availability in a village	41.34
	c) Inadequate supply	16.67
9.	Low price to farm produce	83.33
10.	Small sized farms	33.32