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Bridging Research and Extension Gaps of Paddy Yield in Andhra Pradesh, India

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Abstract

Many paddy cultivating farmers in the country are forced to use their limited resources to produce adequate food for their family, leading to the degradation and reduction in potential of these resources. The yield levels of paddy at the farmers' level and in the Front Line Demonstrations (FLDs) conducted in the farmers' fields is not at par with potential yield of the paddy variety. The gap between potential yield of crop variety and yield realized in FLDs refers to Research gap and the yield gap between FLDs and due to farmers' practice refers to Extension gap. The earlier studies conducted in India in general and in Andhra Pradesh in particular highlighted the existence of both research and extension gaps with reference to paddy. It is essential that, the narrowing of both research and extension gaps is not static, but dynamic considering the influence of technological interventions in boosting paddy yields at FLDs level and at farmers' level and also with the improvement of the yield potential of paddy varieties. This calls for integrated and holistic approaches to address these two gaps and with this background, the researcher aimed at this in depth study. The findings revealed that, research gaps are high with reference to weed management and pest management and extension gaps are high with reference to farm mechanization followed by fertilizer management. Reliable source of seed, capital use and frequency of meetings with Scientists or Agricultural Officers significantly influence the extension gaps in paddy. Farmers also prioritized socio-economic and technical constraints and the analysis infers that, it is high time now for the farmers to adopt the planned technological interventions on scientific scale to minimize the extension gaps to the extent possible. As the enabling environment in the State of Andhra Pradesh is highly encouraging for the farmers with relevant policy instruments in the form of subsidized inputs, free power, credit at concessional rates of interest, constructing irrigation projects etc., the adoption of the proposed technological interventions significantly contribute to minimizing both research and extension gaps in paddy cultivation in Kurnool district of Andhra Pradesh.

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Ⅰ. Introduction

The current world population around 6.7 billion (World Bank, 2009) is expected to rise to 9.3 billion in 2050. The world's population will double in the next 50 years, if the current growth rate of 1.3 percent continues (Kendall and Pimentel 1994:198). However, world cereal yields and agriculture production have declined since 1961 (Harris and Kennedy, 1999). India, the world's second most populous country with 1.3 billion inhabitants, is expected to surpass China in roughly seven years. By 2050, India's population is likely to reach 1.7 billion, nearly equal to that of China and the United States combined. Agriculture plays a vital role in India's economy. Over 58 per cent of the rural households depend on agriculture as their principal means of livelihood. Agriculture, along with fisheries and forestry, is one of the largest contributors to the Gross Domestic Product (GDP). The share of agriculture in the GDP in 2012 was 18 per cent and in employment 50 per cent, and that tells a tale: agriculture is becoming less important to the economy while remaining critical to employment.

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With land finite and water increasingly becoming so, food grain production must increasingly come from productivity gains. In spite of significant increasing trends in yields of all major crops from last one decade in the country, the future food security is very challenging, due to vagaries in climatic conditions, decline in area under cultivation and rapid population growth. But by execution of modern technological interventions in the production of crops recently, wide yield gaps have significantly reduced and this paved the path to meet the future food security challenges of the country.

India is the second largest food producer in the world after China. According to Government of India estimates, for the fiscal year 2015-16, the country's total food market valued at US$39.71 billion and is projected to double in the next 10 years. Having successfully attained self-sufficiency in food, India benefits from marginal surplus in production, and is among the leading global producers of fruits and vegetables, milk, cereals, and wheat in 2015-16 (Figure 1).

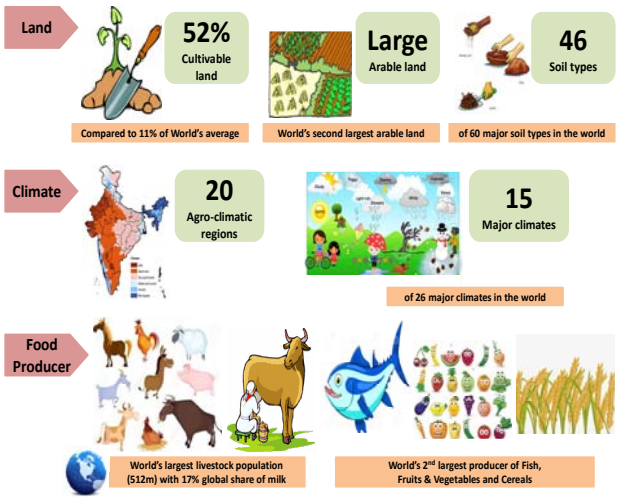


Figure 1 India's competitive edge in Food Production

Paddy is the staple food for Indian population. This crop plays an important role in the national economy of the country, but many paddy cultivating farmers live under the poverty line. Most resource-poor farmers are forced to use their limited resources to produce adequate food for their family, leading to the degradation and reduction in potential of these resources (Dat Van Tran). To achieve national food security, high yielding varieties have been produced to increase paddy production to reach self-sufficiency. India is the second largest producer of rice in the world after China, with a share as large as about 22 per cent of the world's rice production in 2015 (Figure 2). India occupies the second position accounting for about 22 per cent followed by Indonesia with 8 per cent, Bangladesh with 7 per cent and Vietnam with 6 per cent of total rice production in the world. As such, India plays a major role in the rice dynamics of the world. It is interesting that, during the post-green revolution period (beyond 1966-67), the paddy production was increased in India due to significant contribution from productivity rather than area under cultivation (Table 1).

Table 1 Growth (%) in Area, Production and Productivity of Paddy at All-India Level

Period	Area	Production	Productivity
1961-70	0.76**	1.92NS	1.15NS
1971-80	0.91**	2.57*	1.64NS
1981-90	0.60NS	4.22**	3.59**
1991-00	0.05NS	1.17**	1.09**
2001-10	-0.03*	1.59**	1.61**

Note:** Significant at 1% level, * Significant at 5% level, NS – Non-Significant

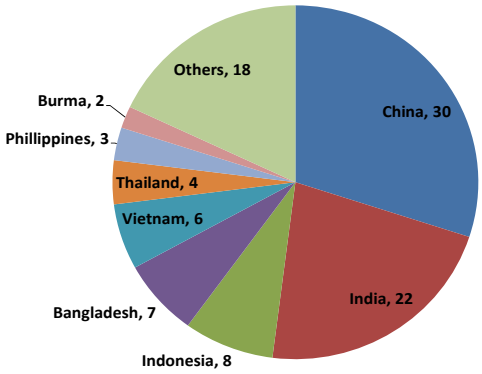


Figure 2 Share(%) of major paddy producing countries in the world(2015)

Determination of potential productivity of a crop say paddy, requires thorough understanding of crop growth and development. The latter, in turn, are dependent upon several climatic, edaphic, hydrological, physiological and management factors. The major factors affecting crop growth and development are radiation, temperature (yield determining), water, nutrition (yield limiting) and pests and diseases (yield reducing). In addition, productivity is also determined by many other factors such as cultivar, its physiology and crop management that interact with weather and soils to influence yield level. In irrigated and well-managed crops, productivity is primarily determined by radiation and temperature whereas in rain-fed areas, precipitation and soil moisture storage are considered important (Aggarwal et al. 2008). It is disappointing that, the yield levels of paddy at the farmers' level and in the Front Line Demonstrations (FLDs) conducted in the farmers' fields is not at par with potential

yield of the paddy variety. Such yield gaps have at least two components. The first component is mainly due to factors which are generally not transferable such as the environmental conditions and some built-in component technologies available at research stations. This component of the gaps called Research gaps therefore, cannot be narrowed or is not exploitable. The second component of yield gaps however, is mainly due to differences in management practices, called as Extension gap. This gap exists as farmers use sub-optimal doses of inputs and cultural practices (Herdt, 1996). This extension gap is manageable and can be narrowed by deploying more efforts in research and extension services as well as Governments' appropriate intervention particularly on the institutional issues. So, the gap between potential yield of crop variety and yield realized in FLDs refers to Research gap and the yield gap between FLDs and due to farmers' practices refers to Extension gap. The earlier studies conducted in India in general and in Andhra Pradesh in particular highlighted the existence of yield gaps with reference to paddy. Various factors cause exploitable yield gaps in paddy such as, physical, biological, socio-economic, and institutional constraints, which can be effectively improved through participatory research, extension and Government attention. These gaps can be conveniently classified into agronomic gaps, socio-economic gaps, institutional gaps, and mixed gaps according to nature of constraints in realizing the true benefits of technological interventions. Closing these gaps is essential not only to increase paddy yield and production, but also to improve the efficiency of land and labor use, reduce production costs, and increase food security. It is essential that, the narrowing of both research and extension gaps is not static, but dynamic considering the influence of technological interventions in boosting paddy yields at FLDs level and at farmers' level and also with the improvement of the yield potential of paddy varieties. So, this calls for integrated and holistic approaches, to address these two gaps through appropriate policy interventions, understanding of farmers' constraints to higher yields of paddy, deploying new proven technologies for raising paddy production and adequate institutional support to farmers. With this background, the researcher aimed at this in depth study with the following specific objectives:

- To assess both research and extension gaps in cultivating paddy in executing need based technological interventions
- To analyze the determinants and constraints of extension gaps in paddy cultivation.

II. Methodology:

i. Study Area and Sample Size: By virtue of its location and climate, Andhra Pradesh represents a transition from tropical to sub-tropical zone of the country. The climate in the State is predominantly semi-arid to arid and the prevailing rainfall distribution, temperatures and soil conditions are suitable for cultivation of paddy. Regarding Scarce Rainfall Zone (SRZ), though the area under irrigation is only 16 per cent of the total cultivated area, the quality of irrigation water, soil fertility, temperatures and humidity are so congenial for cultivating paddy. However, with the fluctuations in monsoon rains, the productivity of paddy at the farmers' level is highly fluctuating for the past few years and hence, it is felt appropriate to conduct this in depth study in assessing both research and extension gaps in its cultivation. The earlier research studies conducted in SRZ revealed worrisome findings with reference to monocropping of paddy, stagnated yields, increased susceptibility to pests and diseases, escalation in the cost of cultivation of crops, exhausted potential of existing varieties etc. Further, innumerable extension gaps have been witnessed in association with these research gaps and these gaps adversely influences the economic prospects of paddy cultivation in SRZ. In view of this, the researcher has made an attempt on the lines of assessing both research and extension gaps and plan relevant strategies, so as to make the paddy cultivation a viable perspective in SRZ. Four different institutions working in SRZ that are conducting FLDs (technological interventions) in cultivating paddy viz., Regional Agricultural Research Station (RARS), Nandyal; District Agricultural Advisory and Transfer of Technology Centres (DAATTC), Kurnool; Krishi Vigyan Kendras (KVKs), Banaganapalli; and State Department of Agriculture are purposively selected. A total of five technological interventions (Table 2), which are commonly executed by all these institutions were purposively selected to ascertain both research and extension gaps. Two villages and 50 farmers have been randomly selected with reference to each Governmental agency in executing the selected technological interventions. Thus four governmental agencies, 8 villages 200 farmers and five technological interventions forms the sample base for this in depth study (Table 2 and Figure 3).

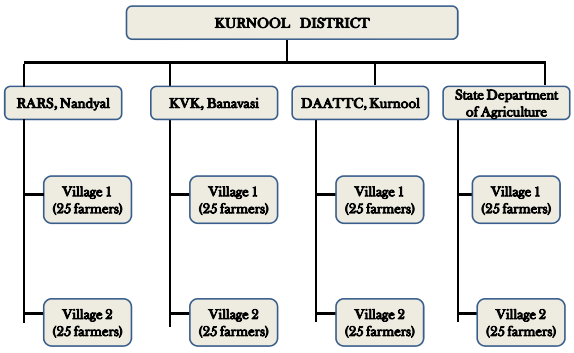
ii. Data and its sources: The present study was mainly based on primary data (sample farmers) like cost of

cultivation, FLD yield data, yields recorded at farmers' level, market prices of paddy etc., for the period 2001-02 to 2016-17. The study was conducted in the year 2017-18. Most of the required secondary data are obtained from the selected institutions viz., RARS, Nandyal; DAATTC, Kurnool; KVK, Banaganapalli; and Department of Agriculture and the data are triangulated with the sample farmers to ensure their reliability.

Table 2 Selected technological interventions in paddy cultivation

Priority area identified	Technological intervention	No. of Sample Farmers
1. Production technology of paddy	SRI technology vis-à-vis Transplanting technology	45
2. Mechanization in paddy cultivation	Mechanized operations vis-à-vis Manual operations	33
3. Fertilizer management in paddy cultivation	Integrated Nutrient Management vis-à-vis Inorganic fertilizers application	57
4. Weed management in paddy cultivation	Application of weedicides vis-à-vis Manual labour	31
5. Pesticides management in paddy cultivation	Integrated Pest Management vis-à-vis Chemical pesticides application	34

Figure 3 Methodology followed for selecting sample farmers in Kurnool district of SRZ



Yield gap analysis:

Research gap = Potential yield of a crop - Yield realized in FLDs

Extension gap = Yield realized in FLDs − Yield of crop obtained in farmers' fields

Technology Index = [(Potential yield − FLD)/Potential yield]*100

Determinants of Extension gap of paddy in SRZ: To identify the determinants of yield gaps, multivariate regression analysis was done. Some important variables were taken on the bases of perceptions. The following regression equation was estimated:

$Y = f(X1,X2,X3,X4,X5)$

where, Y = Extension gap of paddy (t/ha);

X_1 = Educational level of farmers;

X_2 = Source of seed (purchased or on farm produced). The variable was quantified as binary variable: Purchased seed = 1, Own farm produced seed = 0;

X_3 = Institutional credit (Rs)

X_4 = Distance from the Institution and farmers' fields

X_5 = Meetings with Scientist or Agricultural Officers (in number on Annual basis)

Limitations of study: This study suffers from the following limitations:

- Limited to paddy cultivation in SRZ of Andhra Pradesh only, as the agro-ecological regions in this zone are unique compared to other zones.
- Higher incidence of biotic stresses when computing the yield gaps is not taken into account
- The data collected from the farmers (technological interventions-wise) are pooled combining both irrigated and non-irrigated farmers.
- Data collected from the sample farmers are based on their memory recall, as they are not maintaining scientific farm records.

III. Results and Discussion:

i. Determination of Research gaps and Extension gaps across different technological interventions of paddy:

To ascertain the gaps in the adoption of selected technological interventions at the farmers level, the yields obtained by the farmers (of their own practices) are compared both with the potential yield of the crop and the yields realized from the FLDs conduced in the farmers fields. It is a known fact that, the potential yield of the variety under any type of technological intervention cannot be realized at the farmers' level and even at the FLDs conducted by the scientific community at the field level. This variation might be due to changes in the agro-climatic conditions, differences in managerial abilities across the farmers, farm infrastructural facilities available at different locations, soil heterogeneity etc.

However, the review of past studies in India in general,

and in Andhra Pradesh in particular, revealed a disappointing picture regarding the wide disparity in yields of paddy with reference to FLDs and farmers' practices, when compared to the potential yield of the selected variety. With this back ground, this study was attempted to analyze both research and extension gaps in executing different technological interventions in cultivating paddy in Kurnool district of Andhra Pradesh and the same are shown through Tables 3 to 7.

a. Technological Intervention I - Production technology of paddy: In spite of several recommendations and suggestions given by the scientific community with reference to the adoption of SRI technology of paddy instead of transplanted technology especially in water scarcity areas of Kurnool district, the farmers are still going for transplanted technology. The informal discussions held with farmers revealed that, they are preferring transplanted technology, as they are more acquainted with the technology and it is less labour intensive compared to SRI technology. Especially the farmers of the head reach of KC Canal and Telugu Ganga Project opined that, they enjoy adequate irrigation facilities and hence, they prefer transplanted technology. However, this posed threat to the tail end farmers with limited water supplies and thereby, they suffer from low and stagnated yields under transplanted technology. Keeping these aspects in view, the DAATTC, Kurnool RARS, Nandyal, Line department of Agriculture etc., have suggested the farming community especially in the tail reaches of canal commands to go for SRI technology of paddy, as it facilitates the farmers with the following advantages:

- Demands less irrigation water.
- Sustains soil health, as SRI technology lays more emphasis on organic nutrition compared to inorganic chemical fertilizers.
- Though SRI technology demands more labour usage, the rise in labour costs will get outweighed by the drastic increase in yield.
- Both physical and economic efficiency of irrigation water usage in SRI technology is considerably higher over transplanted technology.

To promote the SRI technology among the farmers, the scientific community in the district conducted several FLDs in the farmers' fields, as these demonstrations reflect the true picture about the SRI technology in the practical environment and helps to convince the farmers about the meritorious aspects (as discussed above) of the SRI technology over transplanted technology. A close perusal of the Table 3 reveals a disappointing the picture, as both research gap and extension gap are found significantly high. It is also evident from the table that, though the cost of cultivation in FLDs (SRI technology of paddy) is considerably higher than farmer's practice (Transplanted technology), the drastic increase in the yields of paddy in SRI technology has boosted the net returns over transplanted technology. However, there exists significant research gap even in the adoption of SRI Technology (FLDs) and this is due to impurity of seed, biological constraints such as weeds, pest and disease infestation, problematic soils etc. As expected, extension gap is more than research gap and this is because socio-economic constraints of farmers (like inadequate credit availability, spurious inputs available in the market etc) are added to the above constraints.

b. Technological intervention II – Mechanization in paddy cultivation: With drastic increase in the labour costs, shortage of agricultural labour, noticing the importance of cost effective production of agricultural commodities etc., the Government stressed the promotion of farm mechanization among the farming community. It is to be noted that, besides above advantages farm mechanization also ensures timeliness of Agricultural operations considering meritorious aspects, the scientific community working in RARS, Nandyal DAATTC, Kurnool have executed a number of FLDs in the farmers fields highlighting the importance of farm mechanization viz., paddy transplanter, drum, seeder, puddlers, thresher, marker, conoweeder, harvester, power sprayer, winnower etc., in paddy cultivation.

Despite the execution of these FLDs in the farmers' fields, there is a significant research gap (Table 4). This result is far below the expectations or promises of farm mechanization. Of course, this research gap cannot be attributed due to the inefficiency of machinery usage, but due to sub-divided and fragmented land holding of the farmers. So, the full exploitation of machinery usage efficiency is not realized in FLDs. This was further exaggerated in terms of extension gap at the farmers' level. Besides subdivided and fragmented land holdings at the farmers level, other factors like lack of awareness among the farmers regarding the importance of mechanization

and the higher demand for custom-hiring of machinery (due to acute labour shortage) led to the delay in the performance of farm operations in time has contributed for short fall in yield at the farmers' level and this results in widening of extension gap.

It is essential to note that, though farmers employ machinery (usually on custom hiring basis), they could not exploit the mechanization in terms of cost reduction and this is due to the following factors:

- drastic increase in demand for custom hiring of machinery
- increase in hiring costs of machinery
- availability of machinery is not scale neutral i.e., the purchase of machinery is affordable only by the large farmers.

c. Technological intervention III – Fertilizer management in paddy cultivation: Balanced nutrition in paddy cultivation is gaining more significance, as it directly influences the output of paddy and thereby, food security needs of mounting population. It is disheartening to note that, in spite of several recommendations offered by the scientific community and line department personnel of agriculture, the farmers are still going for higher doses of fertilizer application that too chemical fertilizers only, without addressing the soil test results. Considering these demerits, the scientific community is the district have organized FLDs in the farmers fields highlighting the importance of integrated nutrient management. The FLDs conducted incorporate all compatible methods of nutrient applications such as chemical fertilizers, bio-fertilizers, organic manures etc., considering the results from soil testing.

However, the extension gap at the farmers' level with reference to this technological introversion is significantly high, highlighting the indiscriminate use of chemical fertilizers by the farmers in their fields (Table 5). The informal discussions held with the sample farmers and the same when triangulated with the scientific community revealed interesting aspects that, the sample farmers are completely aware about the scientific recommendations of fertilizers application. But, the farmers are still going for indiscriminate use of chemical fertilizers, especially urea fertilizer by closely observing the neighboring farmers' practices. The samples farmers are with the false impression that, they may get lesser yields compared to the neighbouring farmers, as they are going for higher doses of N- fertilizer application. However, this view was proved wrong, as evident by the insignificant research gap.

d. Technological Intervention - IV Weed management in paddy cultivation: Weed management in paddy is found to be crucial considering two important aspects viz. weeds compete for plant nutrients along with the main crop and thereby, there is wastage of resources at farmers' level and drastic increase in the labour costs for weeding operations. In view of these, the scientific community in the district have executed FLDs highlighting the comparative picture between weeding by herbicides and weeding by human labour. The results have shown that, the extension gap at farmers' level is much higher (Table 6), as the farmers are still going for manual weeding only, even at higher labour costs. This is because, though farmers are aware of benefits of herbicides, they are not adopting the same in the context of specious chemicals flooded in the market and these may affect the main crop growth. The farmers further expressed that, due to acute labour shortage, they could not perform the weeding operations in time. All these factors have led to the escalating of labour costs coupled with the drastic fall in yields thereby, significant increase in the extension gap.

e. Technological intervention V - Pest Management in paddy cultivation: Pest management on agricultural crops is gaining more significance with the stipulation of SPS standards for agricultural commodities to get traded in the international market. Keeping in view of this, the scientific community has been recommending the farmers to go for IPM technology in paddy cultivation. This is because, the IPM technology will ensure less amount of pesticides residues in the produce. Hence, FLDs are conducted in the farmers' fields to disseminated the IPM technology. However, at the farmers' level, the extension gap is higher (Table 7) due to the following reasons:

- The farmers are spraying the chemical pesticides indiscriminately and this is adversely influencing the economics of crop production in two ways viz., affecting the quality of produce with high pesticidal residues and there is decline in net returns.
- The farmers generally presume that, biological methods of pest control are less effective and hence,

they resort only for application of chemical pesticides that too at indiscriminate level.

- Though farmers are applying chemical pesticides, the pest control is not effective as expected due to spurious pesticides flooded in the market.
- The crop varieties cultivated by the farmers are highly susceptible to the local pests and diseases. But, the farmers still prefer to cultivate these varieties only, on account of meritorious features like high yields, good quality of the grain, fetches higher prices in the market etc. However, the low research gap with reference to this technological intervention is an heartening aspect and this will encourage the farmers to enjoy the real benefits offered by the IPM technology.

A close review of the above five technological interventions reveal that, the extension gap at the farmers' level is significantly high and is posing alarming signals to the scientific community to move the things in the right direction by guiding the farmers towards the adoption of these interventions on scientific scale. This is because, India enjoys trade advantage with reference to paddy in the international market and in this context, it is essential to go for cost effective production of paddy, where the above discussed technological interventions serve this objective. To study the relative importance of the above five selected technological interventions, the average values pertaining to both research and extension gaps and also in terms of percentage have been worked out and all the sample farmers were asked to prioritize these interventions.

Comparisons of Research and Extension gaps of paddy yields: The findings portrayed through Tables 3 to 7 and Table 8 reveals that, the research gaps (or Technology Index (%)) are high with reference to weed management and pest management. Regarding extension gap, it is highest with reference to farm mechanization followed by fertilizer management (Figure 4). This is expected in the sense that, all the farmers are not affordable to purchase owned machinery and as discussed earlier, the demand for custom hiring of machinery is high. However, the informal discussions held with the sample farmers pertaining to ranking of technological interventions indicated that, pest management intervention deserves special mention from the farmers in view of the frequent occurrence of pest and diseases problems in the study area. Further, the farmers opined that, this intervention (IPM) should be popularized among the farming community, in view of the sale of spurious chemical pesticides in the market. Next to pest management intervention, farmers ranked fertilizer management and production technology as prioritized interventions in view of indiscriminate use of chemical fertilizers and preferring to go for SRI technology of paddy in the water deficit tail end canal fed areas respectively.

Table 8 Comparisons of Research and extension gaps of paddy yields (t/ha) in Kurnool district of SRZ (Avg. of 2001-02 to 2016-17)

Technological interventions	Potential Yield	FLD	FP	Research Gap	Extension Gap	Technology Index (%)	Extension Gap (%)
I. Production technology of paddy	11.231	9.644	5.990	1.587	3.654	14.13	37.88
II. Mechanization in paddy cultivation	11.231	9.687	5.782	1.545	3.905	13.75	40.32
III. Fertilizer management in paddy cultivation	11.231	9.536	5.718	1.695	3.818	15.09	40.06
IV. Weed management in paddy cultivation	11.231	9.492	5.732	1.739	3.760	15.48	39.62
V. Pest management in paddy cultivation	11.231	9.496	6.050	1.735	3.450	15.45	39.29

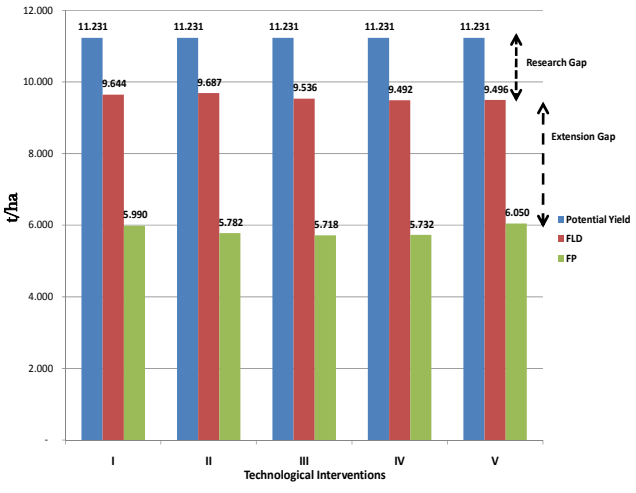


Figure 4 Research and Extension Gaps of Paddy yields in Kurnool district of SRZ(Avg of 2001-02 to 2016-17)

ii. Determinants of Extension gap of paddy in SRZ: To identify the determinants of extension gap of paddy in SRZ, correlation and regression analysis was done in step by step. The regression results (Table 9) of all the sample farmers across the selected technological interventions revealed that 'source of seed (X_2), capital use (X_3) and frequency of meetings with Scientists or Agricultural Officers (X_5) had significant negative effect (at 1% level) on extension gap across all the farmers indicating that, an increase in the magnitude of these variables will minimize the extension gap in the paddy yield. Increase in educational level of farmers (X_1) also contribute to minimizing the extension (yield) gap of paddy.

Table 9 Determinants of Extension gaps of paddy (n = 200)

Variables	Coefficients
Intercept	6.152 (2.124)
X_1=Educational level of farmers	-0.147* (0.071)
X_2=Source of seed (purchased or on farm produced).	-0.992** (0.314)
X_3=Institutional credit (Rs)	-0.863** (0.217)
X_4=Distance from the Institution and farmers' fields	0.017 (0.216)
X_5=Meetings with Scientist or Agricultural Officers	-1.719** (0.354)
R2	0.84**

Note: ** Significant at 1% level; * Significant at 5% level

iii. Constraint analysis of yield (extension) gaps: There are two categories of constraints which are responsible for widening yield (extension) gaps viz., socio-economic and technical constraints. The informal discussions held with the sample farmers revealed that, socio-economic constraints can limit the yield of paddy up to 20-25% and technical constraints have also been found reducing yield up to 30-35%. Therefore, it was necessary to investigate about the constraints faced by the farmers, contributing to the wide yield (extension) gaps.

a. Socio-economic constraints: Six major socio-economic constraints were identified, which are limiting the attainable yield of paddy in the farmers' fields (extension gap). The analysis of the socio-economic constraints (Table 10) revealed that, non-availability of labour at peak season (transplanting of paddy seedlings in main field and harvesting) dominates the list with frequency of 142 (71%) followed by high cost of cultivation using improved practices with frequency distribution of 128 (64%). Poor quality of seed and high prices of fertilizers and pesticides are one of the grave constraints reflected by 122 (61%) and 108 (54%) farmer respondents respectively and have got III and IV ranks respectively.

Table 10 Socio-economic constraints faced by the paddy farmers in Kurnool district of SRZ (n=200)

Constraint	Frequency (Percentage)	Mean Score	Rank
Non-availability of labour at peak season	142 (71%)	69.18	I
High cost of cultivation using improved practices	128 (64%)	64.12	II
Poor quality of seed	122 (61%)	61.29	III
high prices of fertilizers and pesticides	108 (54%)	54.99	IV
High prices of seeds	97 (49%)	49.17	V
Poor quality of fertilizers and pesticides	91 (46%)	47.94	VI

b. Technical constraints: Similarly, six major technical constraints were identified for the extension gaps of paddy yield in farmers' fields. Analysis of these constraints (Table 11) reveal that, 'no seed treatment' dominates the list with frequency of 158 (79%). Late sowing or transplantation due to delayed onset on monsoon rains or late release of canal water is second most constraint found in the SRZ pinpointed by 152 (76%) farmer respondents. High seed rate is third ranked constraint with frequency of 136 (68%) followed by ineffective plant protection measures have frequency of 118 (59%). Ineffective extension mechanism has been revealed by about 104 (52%) farmers and strengthening extension network in the SRZ needs proper attention.

Table 11 Technical constraints faced by the paddy farmers in Kurnool district of SRZ (n=200)

Constraint	Frequency (Percentage)	Mean Score	Rank
No seed treatment	158 (79%)	71.23	I
Late sowing or transplantation	152 (76%)	70.12	II
High seed rate	136 (68%)	67.13	III
Ineffective plant protection measures	118 (59%)	57.21	IV
Ineffective extension mechanism	104 (52%)	53.26	V
Deficient nutrient management	93 (47%)	48.76	VI

iv. Views on the Potential of Narrowing Yield Gaps: The informal discussions held with the sample farmers and scientific community highlighted two different views to address them in view of the complexity of the problem in SRZ. First, those farmers whose are practicing paddy cultivation at the tail end command complained that, lack of adequate irrigation water especially during critical moisture sensitive stages of paddy is mainly responsible for larger yield gaps. In such case, the large yield gaps of paddy could still be exploitable for further improvement in productivity. This can be done through scientific crop management and necessary institutional support, especially input and farm credit supplies. However, the second view is that, the existing yield gaps in paddy are not that much significant for exploitation for further increasing paddy yield and production. This situation is found in head reach of canal commands and farmers with bore well irrigation. Under this situation, further increase in yield is possible only with the deployment of new technologies, such as hybrid rice.

v. Challenges in narrowing the yield gap: The narrowing of the yield gap of paddy in SRZ of Andhra Pradesh (as shown in the above cases), requires integrated and holistic approaches (Tran, 1997), including appropriate concept, policy intervention, understanding of farmers' actual constraints to high yield, deploying of new technologies and promotion of integrated crop management, adequate supplies of inputs and farm credit, and strengthening of research and extension and the linkages among the factors. If one of these components is missing or weak, the yield gap in paddy production area of SRZ cannot effectively be narrowed. It is to be understood that, addressing the issue of narrowing the yield gaps aims not only to increase paddy yield and production, but also to improve the efficiency of land and labour use, to reduce the cost of production and to increase sustainability. Thus, the narrowing of the yield gap is not static but dynamic with the technological development in paddy production, as the gaps tend to enlarge with the improvement of yield potential of paddy varieties. The role of Government is very crucial in addressing and finding solutions for socio-economic inequalities to narrow the yield gaps between research stations and farmers' fields. Pilot studies need to be conducted in different agro-ecological regions of the SRZ to identify actual and potential constraints to paddy production, as the major constraints to high yield may vary from one place to another and should be well understood. A group of agronomists, economists and statisticians should carry out this preliminary survey. Based on the results of the survey, for practical purposes, yield gaps should be estimated and then, need based technological interventions should be planned. Above all, integrated crop management is to be encouraged among the farmers to narrow down extension yield gaps and at the same time, it will help the farmers to recycle the limited resources.

IV. Conclusions and Suggestions: The above discussion reveled that, both research and extension gaps are prevalent with reference to the selected technological interventions, though scientific community and other stakeholders have been actively involved in disseminating their importance to the farmers. Research gaps are high with reference to weed management and pest management and Extension gaps are high with reference to farm mechanization followed by fertilizer management. The determinants like reliable source of seed, capital use and frequency of meetings with Scientists or Agricultural Officers exerted significant negative influence on the extension gaps across all the farmers cultivating paddy. Non-availability of labour at peak season followed by high cost of cultivation of paddy, poor quality of seed and high prices of fertilizers and pesticides are the major socio-economic constraints explained by the farmers for extension gaps in paddy. Regarding technical constraints, the farmers prioritized not practicing seed treatment followed by late sowing or transplantation, employing high seed rate and ineffective plant protection measures. So, it is high time now for the farmers to adopt planned technological interventions on scientific scale to minimize both research and extension gaps to the extent possible. As the enabling environment in the State of Andhra Pradesh is highly encouraging for the farmers with relevant policy instruments, the adoption of the proposed technological interventions significantly contribute towards minimizing both research and extension gaps in paddy cultivation in Kurnool district of Andhra Pradesh. Addressing this issue of yield gaps in paddy production is important for SRZ of Andhra Pradesh, in the context to meet the increasing food requirements of the mounting population.

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Table 3 Technological Intervention I – Production Technology of paddy (n = 45)

Year	Potential yield (t/ha)	Yield(t/ha)		Cost of cultivation (Rs/ha)		Gross returns (Rs/ha)		Net returns(Rs/ha)		Increase in net returns over FP (Rs/ha)	Research Gap* (t/ha)	Extension Gap** (t/ha)	Technology Index (%)	Extension Gap (%)
		FLD	FP	FLD	FP	FLD	FP	FLD	FP					
2001-02	11.231	9.494	5.946	21186.31	18106.73	57926.41	36278.75	36740.10	18172.02	18568.08	1.737	3.548	15.466	37.371
2002-03	11.231	9.578	5.891	24252.63	21086.12	58873.67	36210.56	34621.04	15124.44	19496.59	1.653	3.687	14.718	38.494
2003-04	11.231	9.457	5.954	28861.27	25116.56	59631.68	37543.30	30770.41	12426.74	18343.67	1.774	3.503	15.796	37.041
2004-05	11.231	9.599	5.977	32166.45	28952.64	61660.52	38394.10	29494.07	9441.46	20052.61	1.632	3.622	14.531	37.733
2005-06	11.231	9.515	5.901	35002.57	31529.49	62037.23	38474.17	27034.66	6944.68	20089.98	1.716	3.614	15.279	37.982
2006-07	11.231	9.455	5.899	41951.94	37720.67	70120.93	43748.64	28168.99	6027.97	22141.02	1.776	3.556	15.813	37.610
2007-08	11.231	9.543	5.907	44111.28	41098.43	83658.52	51783.60	39547.24	10685.17	28862.07	1.688	3.636	15.030	38.101
2008-09	11.231	9.425	5.919	45912.86	41958.87	97186.55	61034.18	51273.69	19075.31	32198.37	1.806	3.506	16.080	37.199
2009-10	11.231	9.485	5.913	47211.67	45092.69	108245.29	67480.69	61033.62	22388.00	38645.61	1.746	3.572	15.546	37.659
2010-11	11.231	9.536	5.923	51980.89	47363.47	114314.61	71003.09	62333.72	23639.62	38694.10	1.695	3.613	15.092	37.888
2011-12	11.231	9.714	6.047	52685.21	48561.54	107825.40	71656.95	55140.19	23095.41	32044.78	1.517	3.667	13.507	37.750
2012-13	11.231	9.814	6.114	56128.67	48014.62	125619.20	80093.40	69490.53	32078.78	37411.75	1.417	3.700	12.617	37.701
2013-14	11.231	9.624	5.914	53189.18	49268.96	129442.80	80134.70	76253.62	30865.74	45387.88	1.607	3.710	14.309	38.549
2014-15	11.231	9.896	5.921	57147.24	48572.61	138544.00	85558.45	81396.76	36985.84	44410.92	1.335	3.975	11.887	40.168
2015-16	11.231	10.024	6.314	60251.67	49362.14	145348.00	92878.94	85096.33	43516.80	41579.53	1.207	3.710	10.747	37.011
2016-17	11.231	10.147	6.307	59523.42	49785.18	153219.70	95803.33	93696.28	46018.15	47678.13	1.084	3.840	9.652	37.844
AVG	11.231	9.644	5.990	44472.70	39474.42	98353.41	61754.80	53880.70	22280.38	31600.32	1.587	3.654	14.129	37.881

Note: * Research gap = Potential yield - Yield obtained in FLD, ** Extension gap = Yield obtained in FLD - Yield obtained by FP

Technology Index = [(Potential yield – FLD)/Potential yield]*100

Table 4 Technological Intervention II – Mechanization in paddy cultivation (n = 33)

Year	Potential yield (t/ha)	Yield (t/ha)		Cost of cultivation (Rs/ha)		Gross returns (Rs/ha)		Net returns (Rs/ha)		Increase in net returns over FP (Rs/ha)	Research Gap* (t/ha)	Extension Gap** (t/ha)	Technology Index (%)	Extension Gap (%)
		FLD	FP	FLD	FP	FLD	FP	FLD	FP					
2001-02	11.231	9.515	5.556	16008.79	17106.59	58054.54	33899.21	42045.75	16792.62	25253.12	1.716	3.959	15.279	41.608
2002-03	11.231	9.613	5.712	19052.36	20086.86	59088.80	35110.29	40036.44	15023.43	25013.01	1.618	3.901	14.407	40.580
2003-04	11.231	9.595	5.644	22686.10	23946.21	60501.85	35588.58	37815.75	11642.37	26173.38	1.636	3.951	14.567	41.178
2004-05	11.231	9.636	5.734	24872.52	26961.46	61898.20	36833.15	37025.68	9871.69	27153.98	1.595	3.902	14.202	40.494
2005-06	11.231	9.645	5.711	28652.84	30092.12	62884.82	37235.38	34231.98	7143.26	27088.72	1.586	3.934	14.122	40.788
2006-07	11.231	9.565	5.649	33481.95	35207.77	70936.72	41894.57	37454.77	6686.80	30767.97	1.666	3.916	14.834	40.941
2007-08	11.231	9.662	5.683	38006.63	39989.89	84701.73	49819.91	46695.10	9830.02	36865.08	1.569	3.979	13.970	41.182
2008-09	11.231	9.635	5.699	41093.56	42958.62	99351.98	58765.64	58258.42	15807.02	42451.40	1.596	3.936	14.211	40.851
2009-10	11.231	9.545	5.591	43211.24	45192.13	108930.02	63805.95	65718.78	18613.82	47104.97	1.686	3.954	15.012	41.425
2010-11	11.231	9.635	5.719	46052.58	47936.63	115501.39	68557.60	69448.81	20620.97	48827.84	1.596	3.916	14.211	40.643
2011-12	11.231	9.708	5.826	47152.38	47617.52	107758.80	69038.10	60606.42	21420.58	39185.84	1.523	3.882	13.561	39.988
2012-13	11.231	9.742	5.916	48725.68	48962.18	124697.60	77499.60	75971.92	28537.42	47434.50	1.489	3.826	13.258	39.273
2013-14	11.231	9.812	5.905	48624.38	49514.62	131971.40	80012.75	83347.02	30498.13	52848.89	1.419	3.907	12.635	39.819
2014-15	11.231	9.807	5.931	49614.21	50018.28	137298.00	85702.95	87683.79	35684.67	51999.12	1.424	3.876	12.679	39.523
2015-16	11.231	9.912	6.015	50148.63	51472.61	143724.00	88480.65	93575.37	37008.04	56567.33	1.319	3.897	11.744	39.316
2016-17	11.231	9.957	6.219	50974.18	52687.92	150350.70	94466.61	99376.52	41778.69	57597.83	1.274	3.738	11.344	37.541
AVG	11.231	9.687	5.782	38022.38	39359.46	98603.16	59794.43	60580.78	20434.97	40145.81	1.545	3.905	13.752	40.322

Note: * Research gap = Potential yield - Yield obtained in FLD, ** Extension gap = Yield obtained in FLD - Yield obtained by FP
Technology Index = [(Potential yield – FLD)/Potential yield]*100

Table 5 Technological Intervention III – Fertilizer management in paddy cultivation (n = 57)

Year	Potential yield (t/ha)	Yield (t/ha)		Cost of cultivation (Rs/ha)		Gross returns (Rs/ha)		Net returns (Rs/ha)		Increase in net returns over FP (Rs/ha)	Research Gap* (t/ha)	Extension Gap** (t/ha)	Technology Index (%)	Extension Gap (%)
		FLD	FP	FLD	FP	FLD	FP	FLD	FP					
2001-02	11.231	9.352	5.553	17634.56	18213.69	57060.01	33880.91	39425.45	15667.22	23758	1.879	3.799	16.730	40.622
2002-03	11.231	9.456	5.612	20213.63	21198.36	58123.76	34495.62	37910.13	13297.26	24613	1.775	3.844	15.804	40.651
2003-04	11.231	9.407	5.556	24113.46	25226.21	59316.40	35033.69	35202.94	9807.48	25395	1.824	3.851	16.241	40.938
2004-05	11.231	9.346	5.631	27956.38	29063.86	60035.34	36171.52	32078.96	7107.66	24971	1.885	3.715	16.784	39.750
2005-06	11.231	9.359	5.612	30473.43	31638.41	61020.12	36589.90	30546.69	4951.49	25595	1.872	3.747	16.668	40.036
2006-07	11.231	9.408	5.549	36565.27	37839.17	69772.36	41152.94	33207.09	3313.77	29893	1.823	3.859	16.232	41.018
2007-08	11.231	9.379	5.635	40003.17	41189.77	82220.82	49399.11	42217.65	8209.34	34008	1.852	3.744	16.490	39.919
2008-09	11.231	9.404	5.509	40950.21	42067.31	96970.00	56806.44	56019.79	14739.13	41281	1.827	3.895	16.267	41.419
2009-10	11.231	9.356	5.487	44028.96	45185.63	106773.10	62619.07	62744.14	17433.44	45311	1.875	3.869	16.695	41.353
2010-11	11.231	9.406	5.618	45998.81	47478.26	112756.21	67346.84	66757.40	19868.58	46889	1.825	3.788	16.250	40.272
2011-12	11.231	9.668	5.716	46892.26	47851.29	107314.80	67734.60	60422.54	19883.31	40539.23	1.563	3.952	13.917	40.877
2012-13	11.231	9.702	5.861	47826.34	48756.96	124185.60	76779.10	76359.26	28022.14	48337.12	1.529	3.841	13.614	39.590
2013-14	11.231	9.765	5.902	48129.64	49058.18	131339.25	79972.10	83209.61	30913.92	52295.69	1.466	3.863	13.053	39.560
2014-15	11.231	9.802	5.919	48971.59	49752.28	137221.00	85529.55	88249.41	35777.27	52472.14	1.430	3.883	12.728	39.611
2015-16	11.231	9.854	6.016	49591.26	50421.67	142883.00	88495.36	93291.74	38073.69	55218.05	1.377	3.838	12.261	38.949
2016-17	11.231	9.908	6.304	51248.91	51924.47	149610.80	95757.76	98361.89	43833.29	54528.60	1.323	3.604	11.780	36.375
AVG	11.231	9.536	5.718	38787.37	39804.10	97287.66	59235.28	58500.29	19431.19	39069.05	1.695	3.818	15.095	40.059

Note: * Research gap = Potential yield - Yield obtained in FLD, ** Extension gap = Yield obtained in FLD - Yield obtained by FP
Technology Index = [(Potential yield – FLD)/Potential yield]*100

Table 6 Technological Intervention IV – Weed management in paddy cultivation (n = 31)

Year	Potentia yield (t/ha)	Yield (t/ha)		Cost of cultivation (Rs/ha)		Gross returns (Rs/ha)		Net returns (Rs/ha)		Increase in net returns over FP (Rs/ha)	Research Gap* (t/ha)	Extension Gap** (t/ha)	Technology Index (%)	Extension Gap (%)
		FLD	FP	FLD	FP	FLD	FP	FLD	FP					
2001-02	11.231	9.384	5.635	16728.61	18913.87	57255.26	34381.22	40526.65	15467.35	25059.30	1.847	3.749	16.446	39.951
2002-03	11.231	9.499	5.614	18998.27	21086.56	58388.07	34507.91	39389.80	13421.35	25968.45	1.732	3.885	15.422	40.899
2003-04	11.231	9.435	5.654	22367.51	24516.21	59492.96	35651.64	37125.45	11135.43	25990.02	1.796	3.781	15.991	40.074
2004-05	11.231	9.346	5.524	26713.25	28952.76	60035.34	35484.19	33322.09	6531.43	26790.66	1.885	3.822	16.784	40.895
2005-06	11.231	9.415	5.566	29036.47	31529.34	61385.24	36289.99	32348.77	4760.65	27588.12	1.816	3.849	16.170	40.882
2006-07	11.231	9.405	5.724	33306.38	35534.53	69750.11	42450.79	36443.73	6916.26	29527.48	1.826	3.681	16.259	39.139
2007-08	11.231	9.412	5.656	37956.93	40098.12	82510.11	49583.21	44553.18	9485.09	35068.09	1.819	3.756	16.196	39.907
2008-09	11.231	9.452	5.489	38999.86	41058.27	97464.96	56600.21	58465.10	15541.94	42923.16	1.779	3.963	15.840	41.928
2009-10	11.231	9.403	5.681	40867.23	43092.67	107309.48	64833.05	66442.25	21740.38	44701.87	1.828	3.722	16.276	39.583
2010-11	11.231	9.414	5.729	44154.19	46363.91	112852.11	68677.48	68697.92	22313.57	46384.36	1.817	3.685	16.178	39.144
2011-12	11.231	9.497	5.741	44928.61	46871.26	105416.70	68030.85	60488.09	21159.59	39328.50	1.734	3.756	15.439	39.549
2012-13	11.231	9.512	5.812	46523.41	47158.96	121753.60	76137.20	75230.19	28978.24	46251.95	1.719	3.700	15.306	38.898
2013-14	11.231	9.589	5.843	47108.48	48795.61	128972.05	79172.65	81863.57	30377.04	51486.53	1.642	3.746	14.620	39.066
2014-15	11.231	9.615	5.926	48152.64	49016.52	134610.00	85630.70	86457.36	36614.18	49843.18	1.616	3.689	14.389	38.367
2015-16	11.231	9.701	5.981	49058.17	50521.16	140664.50	87980.51	91606.33	37459.35	54146.98	1.530	3.720	13.623	38.347
2016-17	11.231	9.794	6.134	49987.51	51426.31	147889.40	93175.46	97901.89	41749.15	56152.74	1.437	3.660	12.795	37.370
AVG	11.231	9.492	5.732	37180.47	39058.50	96609.37	59286.69	59428.90	20228.19	39200.71	1.739	3.760	15.483	39.625

Note: * Research gap = Potential yield - Yield obtained in FLD, ** Extension gap = Yield obtained in FLD - Yield obtained by FP
Technology Index = [(Potential yield – FLD)/Potential yield]*100

Table 7 Technological Intervention V – Pest management in paddy cultivation (n = 34)

Year	Potentia yield (t/ha)	Yield (t/ha)		Cost of cultivation (Rs/ha)		Gross returns (Rs/ha)		Net returns (Rs/ha)		Increase in net returns over FP (Rs/ha)	Research Gap* (t/ha)	Extension Gap** (t/ha)	Technology Index (%)	Extension Gap (%)
		FLD	FP	FLD	FP	FLD	FP	FLD	FP					
2001-02	11.231	9.398	5.846	16228.62	18106.36	57340.68	35668.61	41112.06	17562.25	23549.81	1.833	3.552	16.321	37.795
2002-03	11.231	9.506	5.881	18963.89	21086.54	58431.10	36149.10	39467.21	15062.56	24404.66	1.725	3.625	15.359	38.134
2003-04	11.231	9.605	5.954	22897.28	25116.87	60564.90	37543.30	37667.62	12426.43	25241.19	1.626	3.651	14.478	38.011
2004-05	11.231	9.496	5.932	26798.76	28952.17	60998.89	38105.03	34200.13	9152.86	25047.26	1.735	3.564	15.448	37.532
2005-06	11.231	9.315	5.889	29492.49	31529.43	60733.24	38395.93	31240.75	6866.50	24374.25	1.916	3.426	17.060	36.779
2006-07	11.231	9.408	5.992	35627.65	37720.81	69772.36	44438.35	34144.71	6717.54	27427.17	1.823	3.416	16.232	36.310
2007-08	11.231	9.392	6.003	38893.83	41098.11	82334.78	52625.18	43440.95	11527.07	31913.88	1.839	3.389	16.374	36.084
2008-09	11.231	9.587	5.889	39785.97	41958.39	98857.02	60724.84	59071.05	18766.45	40304.61	1.644	3.698	14.638	38.573
2009-10	11.231	9.402	6.008	42963.29	45092.57	107298.07	68564.86	64334.78	23472.29	40862.49	1.829	3.394	16.285	36.099
2010-11	11.231	9.398	6.012	45114.51	47363.76	112660.31	72069.99	67545.80	24706.23	42839.57	1.833	3.386	16.321	36.029
2011-12	11.231	9.481	5.891	45896.16	46751.23	105239.10	69808.35	59342.94	23057.12	36285.82	1.750	3.590	15.582	37.865
2012-13	11.231	9.326	6.127	46715.23	48713.61	119372.80	80263.70	72657.57	31550.09	41107.48	1.905	3.199	16.962	34.302
2013-14	11.231	9.615	6.237	47985.31	49052.17	129321.75	84511.35	81336.44	35459.18	45877.26	1.616	3.378	14.389	35.133
2014-15	11.231	9.672	6.298	48256.38	49926.34	135408.00	91006.10	87151.62	41079.76	46071.86	1.559	3.374	13.881	34.884
2015-16	11.231	9.589	6.334	49052.43	51221.34	139040.50	93173.14	89988.07	41951.80	48036.27	1.642	3.255	14.620	33.945
2016-17	11.231	9.748	6.512	49752.34	54231.16	147194.80	98917.28	97442.46	44686.12	52756.34	1.483	3.236	13.205	33.197
AVG	11.231	9.496	6.050	37776.51	39870.05	96535.52	62622.82	58759.01	22752.77	36006.25	1.735	3.446	15.447	36.292

Note: * Research gap = Potential yield - Yield obtained in FLD, ** Extension gap = Yield obtained in FLD - Yield obtained by FP
Technology Index = [(Potential yield – FLD)/Potential yield]*100