Constraints of Rainfed Rice Production in India: An Overview

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Constraints of Rainfed Rice Production in India: An Overview

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Introduction:

Rice is an important staple food-crop, which is grown in a diverse range of climatic and agro-ecological conditions in almost all parts of the world. More than a third of world's population, predominantly in Asia, depends on rice as a primary staple food. In Asia, more than 2.8 billion people derive 35 to 60 per cent of their calories from rice (Swaminathan, 1989). India occupies an important position both in acreage and production of rice. It has the largest area (42.9 million hectares) that accounts for about 27.1 per cent of the total rice growing area of the world. In respect of production, India ranks second after China by contributing 103 million tonnes for 2011-12. However, the average productivity of rice is merely 2177 kg per hectare.

Table-1: Area, Production and Yield of Rice in India from 1950-51 to 2010-11

Year	Area(Million Hectares)	Production (Million Tonnes)	Yield (Kg./Hectare)
1950-1951	30.81	20.58	668
1955-1956	31.52	27.56	874
1960-1961	34.13	34.58	1013
1965-1966	35.47	30.59	862
1970-1971	37.59	42.22	1123
1975-1976	39.48	48.74	1235
1980-1981	40.15	53.63	1336
1985-1986	41.14	63.83	1552
1990-1991	42.69	74.29	1740
1995-1996	42.84	76.98	1797
2000-2001	44.71	84.98	526
2005-2006	43.66	91.79	2102
2006-2007	43.81	93.36	2131
2007-2008	43.91	96.69	2202
2008-2009	45.54	99.18	2178
2009-2010	41.85	89.13	2130
2010-2011	36.95	80.41	2177
Compound Annual Growth Rate (%)			
1950-51 to 1959-60	1.26	4.46	3.15
1960-61 to 1969-70	0.83	1.19	0.36
1970-71 to 1979-80	0.88	1.9	1.01
1980-81 to 1989-90	0.41	3.62	3.19
1990-91 to 1999-00	0.67	2.02	1.34
2000-01 to 2010-11	-0.75	0.73	1.84
1950-51 to 2010-11	0.59	2.51	1.53

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Table-1 gives information on area, production and yield of rice in India from 1950-51 to 2010-11. It is obvious that there has been there was an annual compound growth of 0.59 percent from 1950-51 to 2010-11 in the area of rice. The corresponding figures for production and yield growths were 2.51 percent and 1.53 percent. During 2000-01 to 2010-11, the rate of growth in area became negative due to failure of monsoons that retarded the pace of growth in production (0.73%). Because of impact of green revolution, that is adoption of high yielding production technologies and high yielding rice varieties, the productivity growth reached to the peak of 3.19 percent during 1980-81 to 1989-90. However, it is concerning that in recent years the productivity growth has decelerated.

The trends in rice area and production are shown in figure-1. It is obvious that there have been frequent fluctuations in rice production due to fluctuating trend in rice yield (Figure2). The figures clearly highlight that rice production is subject to varying degrees of risk due to various production constraints of which rainfed farming is one.

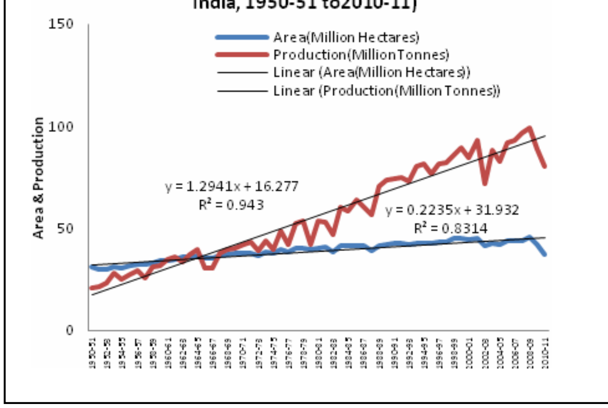

Fig. 1: Trends in Area and Production of Rice in India, 1950-51 to2010-11)

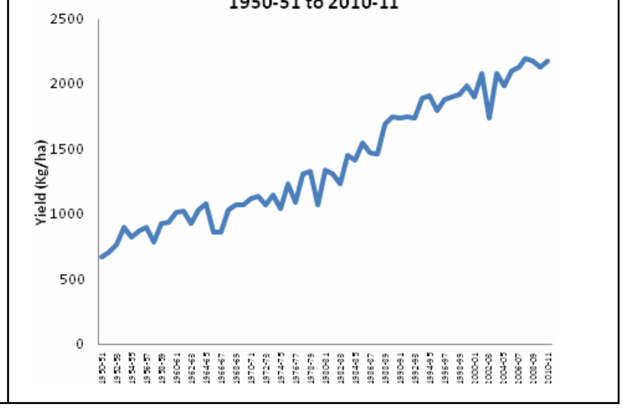

Fig. 2: Trends in Rice Yiled in India 1950-51 to 2010-11

About 12 million ha of the 40.2 million ha rice area cultivated during the rainy season remains uncultivated in the post rainy season (Table-2). It has been mentioned that if the existing rice fallow lands were brought under cultivation, it may usher another green revolution in the pre-dominantly rice-fallow states, benefiting millions of small landholders (Joshi et al. 2002). However, a number of technical, institutional, socioeconomic and ecological factors limit growing of a second crop after rice in rainfed rice fallow lands.

Table-2: State-wise Estimates of Rice Area Cultivated during Rabi (1999-2000)

State	Kharif-Rice Area (000 ha)	Rabi-Fallow (RRFL) (000ha)	RRFL as % of Kahrif-Rice Area	% of RRFL in India
Chhattisgarh	3,584	2,936	81.92	25.0
Madhya Pradesh	2012	1,753	87.12	14.7
Bihar	5,974	2,196	36.8	18.9
West Bengal	4,617	1,719	37.2	14.8
Assam	2,234	539	24.1	4.6
Uttar Pradesh	6,255	353	5.6	3
Others	15,508	2,463	15.9	21
Total	40,184	11,652	29	100

Source : ICRISAT 2009.

Rice is grown under diverse agro-ecosystems. Table-3 presents information on ecologies, area, production and yield of rice in India. It emanates from the table-3 that out of 44.6 million hectares of area under rice about 52 percent is rainfed. The average yield of rainfed rice varied between 1.0 to 1.8 tons/ha whereas irrgated yield of rice was 2.8 ton/ha. It is obvious that there has been a wide variation in the yields of rice under different ecologies.

Table-3 : Rice Ecologies, Area, Production and Productivity in India, 2001-02

Rice ecology	Area		Production		Yield
	Million ha	%	Million Ton	%	Ton/ ha
1. Irrigated	21.6	48	59.8	63	2.8
2. Uplands	6.0	13	6.0	7	1.0
3. Rainfed Lowlands	13.0	30	24.0	25	1.8
4. Deep Water	3.0	7	3.0	2	1.0
5. Coastal	1.0	2	1.2	2	1.2
Total	**44.6**	**100**	**93.1**	**100**	**2.1**

Source : Singh, B. N. 2006. Rainfed Lowland Rice Improvement : Current Status and Future Stratégies. Journal of Rice Research. Vol. 1(1), 104-112.

Table-4 presents rice yield gaps, estimated by Aggrawal et.a . 2008 for soem of the important rice growing states in India. It is obvious that even with the available technologies and cultivars, a huge production gains can be achieved by bridging the yield gaps of rice. There are number of technical and socioeconomic costraints that lead to huge yield gaps in rice.

Table-4 : Yield Gaps in Rrice in India **(kg/ha)**

State	Simulated potential	Experimental potential	On-farm potential	Average
Bihar	3170	1510	820	1830
Karnataka	2280	1440	-	1860
Madhya Pradesh	2590	1540	1600	1910
Maharashtra	2480	-	-	1240
Orissa	2410	1320	2160	1960
Uttar Pradesh	2850	2230	1400	2160
West Bengal	1970	740	1190	1300
India	2560	1480	970	1670

Source: Aggarwal PK, Hebbar KB, Venugopalan MV, Rani S, Bala A, Biswal A and **Wani SP. 2008.** Quantifi cation of Yield Gaps in Rain-fed Rice, wheat, Cotton and Mustard in India. Global Theme on Agroecosystems Report no. 43**.** Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Probably one of the important reasons behind this can be traced out from the lower rice yield in eastern India where rice is grown mainly under rainfed condition.

Rainfed rice based systems of India are home to hundred of millions of the India's poorest people. While modern rice technology has made tremendous contribution for irrigated rice farmers, little impact has been made on the rainfed rice farmers. Eastern India alone accounts for nearly 60 per cent of India's 43 million hectare of rice, of which 80 per cent is rainfed. An estimated 450 million people in the region depend on rainfed rice as their major source of livelihood (IRRI, 1997). But the observation that the green revolution had bypassed the rainfed ecosystem still holds true and raising the predominantly rural population of eastern India out of poverty will require a major increase in agricultural productivity as the final engine of development. A majority of these rice areas are characterized by the resource poor farmers growing traditional varieties with very low level of modern inputs in high risk conditions (Sakarung, 1995). Modern varieties have not been found best suited to rainfed production environments. Due to limited success in developing suitable rice varieties against prevailing natural and climatic conditions viz. drought, flood, submergence, soil salinity etc. these areas have not benefited much even after three decades of Green Revolution (Hossain, 1996). The average rice yield of the eastern India is just 1600 kg per hectare as against the average rice yields in the states like Tamil Nadu (3394 kg\ha), Punjab (3132 kg\ha), and Andhra Pradesh (2499 kg\ha). Hence enhancement of rice yields in the rainfed agro-ecosystems in general and in the eastern India in particular is of prime importance. A number of biotic and abiotic factors, mostly referred to as production constraints, affects the rice yield adversely and hence, needs a special attention so as the growing demand of continuously emerging population of this poor lagging region can be met (Kumar and Jha 2001). This productivity increase will require, among other factors, removal of major constraints to higher yields through research and policy intervention. The first step in this direction is identification of various productions that limits rice yield.

Constraints of rice production:

The production of rice is affected by a number of technical and socioeconomic factors. Constraints to high yield can be classified into two categories; those that affect potential of the crop under farmer's environment; and those that affects farmers ability and willingness to achieve the yield potential on his farm (Barker, 1979). The first category of constraints is related to the development of new production technology and hence the organization of the production potential, given the existing technology and physical environment, and on the other with the degree and equity among farmers and landless workers in access to resource and inputs. Mahapatra (1994) classified different production constraints into six broad categories:

I. Biophysical constraints,
II. Socioeconomic constraints,
III. Administrative constraints,
IV. Institutional constraints,
V. Procedural constraints, and
VI. Technological constraints.

With the inclusion of rice biotechnology programmes, some more classifications like biotic and abiotic constraints came into existence (Widawsky & O'Toole, 1996). In nutshell, the factors restricting adoption of improved technologies and \ or attainment of potential yield may be biotic, abiotic or technical and socioeconomic and \ or combination of these. Often these factors are intertwined with each other and hence the need for a multidisciplinary approach for solving them. Thus, having a brief overview of various production constraints would be helpful in understanding the reasons for low rice productivity under rainfed ecosystem in eastern India and prioritize them accordingly. Subsequent paragraphs present some of the important constraints that have been identified on the basis of previous research works.

Insect-pests:

Insect-pests are serious yield reducing constraints for rainfed rice production in the eastern India. Damage caused by the insect-pests is one of the major components of yield gap accounting nearly 30 per cent of the difference between potential and actual farm yield (Widawsky & O' Toole, 1996). Different studies (Heinrichs, *et.al.*, 1986; Thakur, 1994; Jha, 1998) show that on average 30 to 40 per cent of the total yield loss in eastern India is caused by the insect-pests. Stem borer, gundhibug, brown plant hopper, armyworm, leaf folder, case worm etc. are the major insect-pests of rainfed rice in eastern India. Since damages from these insect-pests are widespread and there is limited natural resistance in locally cultivated varieties of rice, varietal improvement through biotechnology offers critical alternatives to insecticide use. This has a two-fold advantage: it serves to increase yields and reduces the dependency of resource poor farmers on insecticides, thereby addressing environmental concerns.

Diseases:

Occurrence of various diseases in rice varieties grown under rainfed ecosystems in eastern India is very common. Selection of varieties unsuitable for the cultivation on rainfed lands and favourable moist weather harbor a number of rice diseases. As a result an average yield loss of 25-30 per cent per annum due to diseases is a regular feature in eastern India. It was found that occurrence of bacterial leaf blight (generally sporadic), brown leaf spot, and narrow brown leaf spot were severe in years of poor rain falls (Singh and Sahu, 1987). Other important diseases are blast, sheath rot and sheath blight. Bacterial leaf blight and rice blast was found most serious diseases in eastern India (Ramasamy and Jatilekson, 1996). Varietal resistance to disease, particularly bacterial leaf blight and rice blast, are needed against which there is currently no effective genetic resistance. Chemical and cultural controls need to be maintained and search for genetic resistance should be continued.

Weeds:

Weeds are other important constraint as they compete with the rice crop and lead to a substantial loss in production. The yield loss due to weeds in rainfed ecosystems was found to be greater than that of irrigated ecosystems (Moody and De Dutta, *et.al.*1986). In rainfed lowland areas, moist aerobic conditions or shallow water for extended period of flooding during early crop growth, followed by prolonged periods of flooding to variable depths favour the growth of a more diverse weed flora and more competitive weed species and their population. Weeds competed severely with rice, reducing yield by 10-15 per cent depending on such factors as the weed species and their population. Yield losses due to unchecked weed growth ranged from 13 to 40 per cent with a mean value of 25 per cent (AICRP, 1969-1986). As far as rainfed lowland ecosystem is concerned, which is a dominant ecosystem in eastern India studies show that yield loss due to uncontrolled weed growth may be as high as 62 to 75 per cent. Hence, development of fast growing weed tolerant varieties and effective weed management techniques are essential for increasing the rice yield in eastern India.

Rodents:

Apart from insects, diseases and weeds, losses incurred by the rodents are substantial. The damages made by the rodents in rice fields and in storage accounts for about 10 to 18 per cent of the total production. In eastern states where rice is cultivated under rainfed rice lands, production losses due to rodents are significantly high. However, control of rodents is only possible through community approach, which requires more reliable Integrated Pest Management practices and creation of awareness among the farmers.

Abiotic Technical Constraints:

As stated earlier, production of rice is a subject to a set of biotic and abiotic constraints. The reviews of some important abiotic constraints are being presented in following paragraphs.

Non-adoption \ Poor adoption:

Non-adoption of modern varieties as well as their component technologies has been a crucial production constraint under rainfed rice ecosystem. The studies show that the accumulated stock of technologies for rainfed rice production was able to increase yield by 30 to 40 per cent

(Shenoi and Mandal, 1986; Jha, 1998). Almost all constraint studies reveal that the average rice yield achieved on farmers' fields, especially in rainfed rice ecosystem are lower than those commonly obtained in experimental plots (Srivastava *et.al.*,1990). The status of rainfed rice production in eastern India is even more concerning. It was estimated that the actual yield of rainfed rice in eastern India is 86 per cent lower than its potential farm yield. (Dey and Upadhyaya, 1986).

Scarcity of suitable package of practices:

The component technologies developed so far, due to one reason or the other, has failed to satisfy the expectations of rainfed rice farmers. The findings of a number of studies (Thakur, 1994; and Jha, 1998) put forth the need for the development of more doable, problem based, cost effective and area specific technologies for rainfed rice production.

Temperature and radiation:

Rice has a wide range of adaptability. However, it is susceptible to a number of environmental factors. Temperature and radiation are the two other important factors, which play crucial role in the production of rainfed rice in eastern India. The high minimum temperature and radiation during the monsoon seriously limit the yield potential of wet season rice in eastern India unless it is harvested late in the year (Garrity, Oldeman and Lenka, 1986). Occurrence of cold at anthesis affects the rice production seriously. A majority of rice areas in eastern India experiences severe cold in winters and thus observes cold at the time of anthesis in the late transplanted rice. Huke (1982) reported that from high altitudes in north eastern India where low temperature is a constraint to low altitudes where high night temperature limits yield, temperature becomes one of the important production constraints. Therefore, it is important to develop rice varieties, which may withstand vagaries of high and low temperatures, which are phenomenal in eastern states in India.

Recurrent floods and droughts:

Occurrence of recurrent floods and droughts are the regular features in most of the parts of eastern India. A majority of rice area, mostly rainfed, in Assam, North Bihar, Orissa and West Bengal experiences either floods or droughts or even both every year. Nearly 10 million hectares of lowlands in Bihar, Orissa and West Bengal are affected with flash flood and water logging (Prasad, *et. al*.,1986). In contrary, drought and moisture stress are the major limiting factors in upland rainfed rice in these state. Constraint studies on rice in Bihar show that yield losses due to occurrence of floods and droughts are substantial (Thakur, 1994 and Jha, 1999). Nearly, 95 to 100 thousand tonnes of rainfed lowland rice are lost every year in Bihar only. The losses caused by the floods in rainfed up and lowlands in Bihar accounts for about 12 to 27 per cent per annum of the actual production. Different studies reveal that drought is most significantly contributing to the yield gap in upland rainfed rice, where as flash floods submergence is the major constraint of rainfed low land rice (Herdt, 1996). The problem of flood and droughts can not be solved merely through conventional technologies. Biotechnology embraces a range of technical possibilities, the future potential of which is still being hypothesized. However basic research on transfer of drought and flood tolerant genes is distinct possibility.

Water management:

Results of different water management studies show that the production of rice can be increased up to 20 per cent with the help of suitable water management technology. However, indiscriminate use of canal irrigation and drainage is affecting the rice yield adversely. Water management of ill -drained soil in rainfed lands is one of the major constraints (Prasad, *et.al*., 1986; and Hossain and Laborte, 1996). It was found that about one third of total rice, grown in eastern states is rainfed and grown in low topography, problem of drainage depressed rice fields (Shenoi and Mandal, 1986). Hence, introduction of new and efficient water management techniques for rainfed rice production might be helpful in the enhancement of rice yield in eastern India.

Problem soils:

A bulk of soils in eastern states is problematic. Hence, they have become detrimental to the production of rice. Poor soil fertility is common in rainfed uplands where yields are constrained by lateritic soils with high iron and low nitrogen content, and a pH occasionally below five. Soil problem in other rainfed areas includes salinity, alkalinity and \or zinc deficiency. Apart from coastal saline soils of West Bengal and Orissa a majority of rainfed lands in Bihar and Assam are suffering from the problem of soil salinity. While some of these problems may be efficiently solved with affordable soil amendments, other constraints such as alkalinity and salinity cause greater yield losses, which might be partially averted through tolerant high yielding varieties.

Inadequate input use:

Due to fear of crop failure or other input related constraints like, high input costs, unavailability of input on time in required quantity and other technical and socioeconomic constraints, inadequate input use is common in rainfed ecosystem of eastern India. Studies show that application of fertilizer is positively correlated with the availability of irrigation water but uncertainty of rainfall and accumulation of water in fields constrain fertilizer use in rainfed rice fields. Similarly, high cost of agro-chemicals constrains the use of these chemicals and pesticides on the farm. Thus policies are needed to encourage the use of potential biological substitutes to the agrochemicals besides ensuring timely supply of critical inputs. Finally development agencies should make a concerted effort to develop irrigation potential through water harvesting.

Conclusions:

Rice is one of the most important crops in eastern India and it will continue to enjoy its leading position so long as it remains the staple food of almost entire of the population of this region. Under the influence of increasing population pressure the demand for rice is expected to rise persistently in coming years. As the land frontier has already been exhausted the future source of growth in this region lies in raising the productivity of rice crop. Even to sustain in food grains production, it is important to give due attention to the eastern India in general and to accord high priority to the constraints of rice production in this region in particular. This can be achieved if rice research helps to reduce production losses due to various biotic and abiotic constraints in rainfed rice ecosystems. Since elimination or partial solution of these constraints would have a major impact on rice production in eastern India because the yield gaps are very high, the major constraints to rice production in eastern India require more objectivity and concerted efforts while addressing them. The major rice production constraints and priority research problem areas of rainfed rice production in eastern India are drought and submergence, bacterial blight, leaf blast, weeds, brown plant hopper and poor soil fertility. Hence, it would be logical to prioritize rice research on the basis of prevailing constraints under rainfed areas of eastern India. Besides, low input use, inappropriate plant spacing, late sowing and selection of wrong cultivars are some of the other technical constraints, which can be effectively reduced through the diffusion of relevant technologies among ultimate users or farmers. It requires further strengthening of linkages between 'Research & Extension' that facilitates feed-backs and disseminates technical information.

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