POLICY PAPER 64

Improving Productivity of Rice Fallows

NAAS

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI
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CONVENER : Dr Masood Ali, Ex-Director, Indian Institute of Pulses Research, Kanpur

CO-CONVENERS : Dr Sanjeev Gupta, Project Coordinator (MULLaRP), IIPR, Kanpur
Dr A. Sarker, Regional Coordinator, South Asia & China, ICARDA, New Delhi

EDITORS : Dr C. Devakumar
: Dr P.K. Chhonkar

REVIEWERS : Dr Biswapati Mandal, Dr Rajendra Prasad, Dr A.R. Sharma and Dr B. Venkateswarlu

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NASC, Dev Prakash Shastry Marg, New Delhi - 110 012
Tel: (011) 25846051-52; Fax: (011) 25846054
Email: naas@vsnl.com; Web site: http://www.naasindia.org

Preface

Rice fallows basically imply to those lowland *kharif* sown rice areas which remain uncropped during *rabi* (winter) due to various reasons such as early withdrawal of monsoon rains leading to soil moisture stress at planting time of winter crops, waterlogging and excessive moisture in November/December, lack of appropriate varieties of winter crops for late planting, and socio-economic problems like stray cattle, blue bulls etc. India accounts for 79% (11.65 million ha) of the total rice fallows of South Asia (15.0 million ha).

In order to meet domestic demands of edible oil and pulses, a large quantity is imported which leads to huge drain of foreign exchange. The rice fallows offer good scope for area expansion of these crops and crop intensification. Their productive utilization can overcome many social and economic problems like unemployment, labour migration and low income. Development and popularization of improved varieties of pulses and oilseeds suiting to rice fallows of different agro-ecological regions coupled with improved agro-technologies can boost production, and thus improve income and livelihood security of farming community. Moreover, introduction of legumes can provide a sustainable production base to the continued rice mono-cropped system and obviate decline in total factor productivity and also provide much needed nutritional security.

Looking into the importance of rice fallow ecology in Indian agriculture, a Brainstorming Session on "*Improving Productivity of Rice Fallows*" was convened by the National Academy of Agricultural Sciences on April 20, 2013. In addition to the valuable presentations by experts in their relevant areas related to various aspects of rice fallow cultivation, there was active participation from 19 experts from the NARS and State Agricultural Departments. I trust, the carefully structured recommendations in this Policy Paper will be acted upon by all the stakeholders and help utilize the full potential of rice fallow for enhanced and sustained agricultural productivity and economic growth.

On behalf of the Academy, I would like to compliment the Convener Dr. Masood Ali, Ex-Director, Indian Institute of Pulses Research, Kanpur and Co-conveners Dr. A. Sarker, Regional Coordinator, South Asia and China, ICARDA, NASC Complex, New Delhi and Dr. Sanjeev Gupta, Project Coordinator (MULLaRP), IIPR, Kanpur for their contributions. My thanks are also due to all distinguished participants of the Brainstorming Session, Reviewers and the Editors of the Policy Paper.

(R.B. Singh)
President, NAAS

Improving Productivity of Rice Fallows

1. PREAMBLE

Rice fallows basically imply to those lowland *kharif* sown rice areas which remain uncropped during *rabi* (winter) due to various reasons such as lack of irrigation, cultivation of long-duration varieties of rice, early withdrawal of monsoon rains leading to soil moisture stress at planting time of winter crops, waterlogging and excessive moisture in November / December, lack of appropriate varieties of winter crops for late planting, and socio-economic problems like stray cattle, blue bulls etc. (Ali and Kumar, 2009).

India accounts for 79% (11.65 million ha) of the total rice fallows of South Asia (15.0 million ha). Rice fallows are mainly spread in the states of Andhra Pradesh, Assam, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, West Bengal and Uttar Pradesh (Subbarao *et al.*, 2001) (Table 1). The coastal region of Andhra Pradesh, Karnataka and Tamil Nadu form an important rice fallow ecology in peninsular

Table 1. Area under rice fallows in India.

State	*Kharif*-rice area (m ha)		*Rabi* fallow (m ha)	Rice fallow as % of *kharif* rice area
	2001	2010-2011*	2001	
Andhra Pradesh	2.66	2.92	0.31	11.5
Assam	2.23	2.17	0.54	24.1
Bihar & Jharkhand	5.97	2.74 + 1.69	2.20	36.8
Gujarat	0.47	0.73	0.08	17.7
Karnataka	0.98	1.13	0.18	18.5
Madhya Pradesh & Chhattisgarh	5.60	1.60 + 3.70	4.38	78.3
Maharashtra	1.76	1.49	0.63	35.7
Odisha	3.88	3.93	1.22	31.4
Rajasthan	0.21	0.13	0.03	11.7
Tamil Nadu	1.70	1.74	0.02	1.2
Uttar Pradesh	6.26	5.66	0.35	5.6
West Bengal	4.62	3.57	1.72	37.2
Total (All States)	40.18	38.03	11.65	29.0

Source: Subbarao *et al.* (2001); *Figures provided by Dr. A.R. Sharma

India. These rice fallow areas offer a huge potential niche for short season pulses and oilseed crops.

In order to meet domestic demands of edible oil and pulses, a large quantity is imported which leads to huge drain of foreign exchange. The rice fallows offer good scope for area expansion of these crops and crop intensification. Their productive utilization can overcome many social and economic problems of the region like unemployment, labour migration and low income. Development and popularization of improved varieties of pulses and oilseeds suiting to rice fallows of different agro-ecological regions coupled with improved agro-technology will boost production, and thus improve income and livelihood security of farming community. Moreover, introduction of legumes can provide a sustainable production base to the continued rice mono-cropped system leading to decline in total factor productivity and also provide much needed nutritional security.

This policy paper developed through a Brainstroming Session organised by the National Academy of Agricultural Sciences on April 20, 2013 describes the status and prospect of rice fallow ecologies distributed in different parts of India. It discusses the opportunities for the introduction of different crops in rice fallows with best fit technological interventions of crop establishment and integrated crop management. The need for policy support, technology interventions and R&D efforts is also highlighted for improving the productivity of rice fallows.

2. DISTRIBUTION OF RICE FALLOWS

Rice fallows are widely distributed in rainfed ecosystem of eastern, central and peninsular India besides north-eastern hill region. The major districts having larger area in different states are given in Table 2.

Table 2. Major districts under rice fallows in India.

State	Major districts
Andhra Pradesh	Krishna, Guntur, East Godavari, West Godavari, Srikakulum, Nellore and Prakasham
Assam	Lakhimpur, Jorhat, Sibsagar, Dibrugarh, Golaghat, Karbi, Nagaon and Maringon
Bihar	Kisanganj, Sahibganj, Gaya, Aurangabad, Katihar and Bhagalpur
Chhattisgarh	Surguja, Jashpur, Raigarh, Durg, Bilaspur and Baster
Jharkhand	Ranchi, Purbi Singhbhum, Paschim Singbhum, Hazaribagh, Gumala, Sahibganj, Deogarh, Palamau, Dumka and Dhanbad
Maharashtra	Dhule, Amravati, Nagpur, Wardah, Bhandara, Chandrapur and Nanded

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Table Contd...

State	Major districts
Madhya Pradesh	Shahdol, Seoni, Balaghat, Damoh, Mandla, Rewa, Betul and Sidhi
Odisha	Koraput, Kalahandi, Sambalpur, Sundergarh, Bhadrak, Cuttack, Puri, Dhenkanal and Mayurbhanj
West Bengal	Purulia, Bankura, Birbhum, Bardhaman, Medinapur, Murshidabad South 24-Parganas, Maldah, West Dinajpur, Jalpaiguri and Coochbihar
Uttar Pradesh	Gonda, Siddarthnagar, Lakhimpur, Kheri, Pilibhit, Etawah, Mirzapur and Snbhadra
Karnataka	Shimoga and Belgaum
Tamil Nadu	Salem, Namakkal, Tiruchirappali, Cuddalore, Ramnathpuram, Madurai and Villupuram

3. RICE FALLOWS ECOLOGY

In India, rice is cultivated on wide range of soils from loamy sands in Punjab to clayey soils in several states. Heavy-textured soils with high water-holding capacity produce higher rice yields and are suitable for subsequent short-season crops under rainfed conditions. Since rice fallows are distributed in eastern plains, central region, coastal peninsula and north-east hills, the edaphic and climatic conditions vary greatly, which are briefly described below:

Eastern plains: The agro-climate of the region is characterized by hot dry sub-humid climate with hot summers and cool winters. In West Bengal, it is moist sub-humid. The mean annual temperature ranges between 24-26°C. The mean summer (April-May-June) temperature varies from 29-32°C rising to a maximum of 37-42°C in April and May. The mean winter (December-January-February) temperature varies from 16-18°C dropping to a minimum of 8-10°C. The area receives mean annual rainfall of 1200-1500 mm increasing towards the eastern side (West Bengal) to 1600 mm. Potential Evapo-Transpiration (PET) ranging between 1400-1700 mm. The growing period of this sub-region begins with the onset of monsoon in July and ends in December. The length of growing periods (LGP) ranges between 180-210 days in eastern Uttar Pradesh, Bihar and Jharkhand, and exceeds 240 days in West Bengal. The soils are deep, imperfectly to poorly drained, loamy to fine loamy in texture. In Ghagar flood plains in Bahraich district of Uttar Pradesh, the soils are coarse loamy, strongly alkaline, moderate to high calcareous and highly base saturated. The period during July to September is humid with water surplus of 200-300 mm.

Central region: The agro-climate of this region is characterized by transition between hot dry sub-humid and moist sub-humid, with dry summers and cool winters.

The mean annual air temperature varies from 25-28°C. The mean annual summer (April to June) temperature varies between 30-33°C and may rise to a maximum of 34-42°C in May. The mean winter (December to February) temperature varies from 17-21°C and may drop to a minimum of 8-13°C in January.

The area receives mean annual rainfall of 1200-1600 mm, which covers >85% of annual demand of PET (1400-1700 mm). However, south-east Madhya Pradesh and Wardha region of Maharashtra receive 1000-1200 mm rainfall. The LGP in this region is 150-180 days whereas in Jagdalpur area of Chhattisgarh, it extends up to 210 days. The soil moisture is available from the second half of June to November, with total water surplus ranging from 300-550 mm.

In Chhattisgarh, the soils are silty clay to clay, deep and fine loam, moderately alkaline and calcareous. In south-east Madhya Pradesh, the soils are deep to very deep, clayey, mildly to moderately alkaline (vertisols), and also silty clay to silty clay loam. In Satpura range, the soils are medium deep to deep clayey and also clay loam. However, in Wardha region of Maharashtra, the soils are deep to very deep, clayey and loamy to clayey.

Coastal peninsula: The agro-climate of the coastal Andhra Pradesh is characterized by dry sub-humid with hot summers and very mild winters. The mean annual temperature varies from 26-29°C rising to a maximum of 39-40°C in May and June and dropping to a minimum of 20-22°C in January. The mean annual rainfall ranges from 1000-1200 mm meeting 60-70% of the PET demand (600-1800 mm). The moisture availability period begins with the onset of rainfall in September, and continues up to November / December and ends with the utilization of stored soil moisture in January. In Godavari delta, rainfall is high (up to 1500 mm) and growing period extends up to 210 days. The soils are deep and clayey.

The agro-climate of coastal Karnataka is characterized by tropical hot and humid summers, and wet and mild winters. The mean annual temperature remains more or less uniform throughout the year (27-28°C) indicating tropical conditions. The temperature rises to a maximum of 33-36°C in summer months (March and April), and drops to 22-24°C in winter months (December and January). The area receives pre-monsoon showers during the last half of April, and the south-west monsoon sets in the area from May and extends up to first half of December. During this period, the area receives 95% of annual rainfall. The soils are red and clayey skeletal.

North-east hills: The agro-climate of the sub-region is characterized by humid ecosystem with hot summer and cool winter. The mean annual temperature varies from 24-25°C, rising to a maximum of 30-32°C in May and June, and dropping to a minimum of 10-12°C in December and January. The mean annual rainfall ranges from 1600 to 2000 mm in central Brahmaputra valley. The period of utilization of the stored soil moisture after the cessation of rainfall extends from the second half of November to the end of February, followed by a short seasonal summer water deficit in the month of March extending to the first half of April. The LGP extends from May to February accounting for 240-300 days. The soils are deep clay loam.

In upper Brahmaputra plains, the agro-climate is characterized by per humid ecosystem with hot summers and cool winters. The mean annual temperature varies from 23-24°C, rising to a maximum of 31°C in June and dropping to a minimum of 10-11°C during December and January. The mean annual rainfall ranges from 2500 to 3000 mm. The rainfall breaks by the end of March / April and continues till October exceeding PET, while the precipitation declines seasonally during November, December and January. The moisture index of the area in upper Brahmaputra plain exceeding + 100 suggests the prevalence of high humid condition in the area. The soils are deep fine loamy, sandy clay to clay.

4. POTENTIAL CROPS FOR RICE FALLOWS

After the harvest of *kharif* rice, climatic conditions of rice fallow lands in many areas are suitable for growing cool and warm season pulses profitably. The residual moisture left in the soil at the time of rice harvest is often sufficient to raise short-season crops. Further, by use of short-duration and high-yielding varieties of rice allowing to vacate fields in September-October, the traditional rice fallows can be converted into productive lands. Introduction of cool and warm season pulses such as lentil, mungbean, urdbean, lathyrus, peas etc. in rice fallows can increase the productivity as well as sustainability of rice. The small-seeded varieties of these pulses may find prominence under *Utera* cultivation (relay cropping) in the states of Chhattisgarh, Jharkhand, Bihar, West Bengal and Assam. This practice can be made more effective by using short-duration and high-yielding varieties of rice, as rice crop will vacate the field in September-October. In low land areas with excessive soil moisture, lentil is more suitable and assured than chickpea. Consequently, the rice-lentil system can be made more popular in the lowlands of eastern Uttar Pradesh, Bihar, Jharkhand and West Bengal. Introduction of groundnut in rice fallows can be a profitable proposition in *Char* area of Bihar and eastern Uttar Pradesh, Mahananda of Odisha, Brahmaputra valley of Tripura, Assam, Meghalaya, Manipur, and coastal Andhra Pradesh. Under zero-till, mustard in eastern Uttar Pradesh has good scope besides traditional urdbean and mungbean. Of late, *rabi* sorghum has also been successfully introduced in the rice fallows of coastal Andhra Pradesh (Patil *et al*., 2012). Suitable crops for different rice fallow areas are given in Table 3.

Table 3. Potential crops for rice fallows in different states.

Crop	State
Lentil	Assam, West Bengal, Bihar, Odisha, Eastern Uttar Pradesh, Chhattisgarh and Jharkhand
Grasspea (lathyrus)	*Tal* area of Bihar, Chhattisgarh and West Bengal
Pea	Jharkhand, Chhattisgarh, Eastern Uttar Pradesh and northern Madhya Pradesh
Chickpea	Chhattisgarh, Bihar and Jharkhand
Mungbean	Odisha, Chhattisgarh, Jharkhand, Bihar, Andhra Pradesh, Tamil Nadu and Karnataka.
Urdbean	Coastal Andhra Pradesh, Tamil Nadu, Karnataka and Odisha
Clusterbean	Andhra Pradesh, Tamil Nadu and Karnataka
Lablab bean	Andhra Pradesh, Tamil Nadu and Karnataka
Mustard	Eastern Uttar Pradesh, Bihar and Jharkhand
Groundnut	*Char* area of Bihar, Mahananda of Odisha, Brahmaputra valley of Assam and coastal Andhra Pradesh

5. PRODUCTION CONSTRAINTS OF RICE FALLOWS

A feasibility study (Pande *et al.*, 2012) on growing chickpea in the rainfed rice fallow land (RRFL) of eight selected districts of Madhya Pradesh and Chhattisgarh elicited mixed response of farmers identifying the major constraints such as biotic and abiotic stresses, poor crop management practices, lack of awareness about modern methods of cultivation including quality seed of high yielding varieties and integrated pest management, poor linkage to market and government support price policies. Addressing these major constraints through appropriate interventions will pave way in increasing chickpea production and improving the well-being of resource-poor farmers in these states.

Lack of improved varieties and quality seeds: Crop varieties specially suited for rice fallows of different regions have not been developed, and therefore, among the available varieties which have comparative advantage should be recommended. There is an acute shortage of quality seeds of recommended varieties, compelling farmers to grow low-yielding local varieties.

Poor plant stand: Under relay (*utera*) cropping, plant population is often low due to poor seedling emergence on account of compact soil, poor contact of seed with soil and low soil moisture in surface layer. In some areas, seed rotting due to excessive moisture is also observed.

Weed menace: Weeds are a serious problem under *utera* cropping as there is no land preparation. Hand weeding is a difficult proposition due to fast drying of soil surface. In many areas, cuscuta infestation is also associated with urdbean and mungbean (Satyanarayana *et al*., 1997). Use of pre-emergence or pre-plant herbicides is not feasible under these conditions.

No use of fertilizers: In rice fallows, generally no manure or fertilizer is applied due to no-tillage practice under relay planting, and consequently the crops suffer due to nutrient stress. Further, the physical condition of soil is poor due to transplanted puddled rice and consequently nutrient mobilization is reduced. Due to puddling for transplanting of rice and anaerobic conditions, rhizobial populations are considerably reduced which limit biological N_2 fixation. In addition, the mono cropped rice cultivation also creates nutrient imbalance in the soil.

Terminal drought: Since *rabi* crops are grown on residual soil moisture under rainfed conditions, terminal drought severely affects crop productivity. Drought onset accelerates leaf senescence, and decreases net photosynthesis and translocation from leaf to developing grains. Further, the accumulation of poor biomass often does not support the grain filling at reproductive stages. Terminal drought and heat stress result in forced maturity and may reduce seed yield by 50% in the tropics. The probability of winter rains in central and eastern plains is quite low.

Prevalence of diseases: Powdery mildew is a serious disease of *rabi* planted urdbean and mungbean in coastal peninsula. Similarly, rust and *Fusarium* wilt are common in lentil. In chickpea, dry root rot and wilt in central zone, and *Botrytis* grey mold and collar rot in eastern plains cause severe losses.

Delayed planting: In rice fallows, planting is dependent upon duration of rice varieties, withdrawal of monsoonal rains and soil moisture status which are highly variable. Planting is often delayed which reduces crop yield.

Poor crop management: *Rabi* crops in rice fallows are considered as bonus crop. In view of the risk involved in successful cultivation of second crop due to limiting soil moisture and likely drought situation besides socio-economic problems, farmers do not pay much attention to crop management such as choice of appropriate varieties, seed rate, pest management, rhizobial inoculation, foliar nutrition, mechanization etc.

Socio-economic constraints: Rice fallows are generally invaded by stray cattle and wild animals like blue bulls, boars etc. There is no policy support and other incentives which can motivate farmers to grow pulses in these areas.

6. TECHNOLOGICAL INTERVENTIONS FOR IMPROVING PRODUCTIVITY

In rice fallows, yields of *rabi* crops are generally low as explained above, and thus a large area still remains uncropped. Limited R&D efforts in the past have led to development of improved production technologies which need to be refined and validated for different eco-regions. Table 4 provides the suggested interventions to improve the productivity of rice fallows:

Table 4. Major technological interventions for improving productivity of pulses in rice fallows.

Issues	Interventions
Lack of suitable cultivars	Development of high-yielding varieties with appropriate maturity duration
Poor crop stand and establishment	Tillage machines, sowing methods, seed priming, higher seed rate, timely planting, seed treatment with fungicides
Diseases and pests	Development of IPM modules
Weed menace	Post-emergence herbicides like Quizalofop ethyl and Imazethapyr
Nutrient management	Foliar spray of urea/DAP to supplement N and P
Micronutrient deficiencies	Mo, B, Zn as seed pallets
Terminal moisture/heat stress	Residue mulching
Non-availability of quality seeds	Informal and formal seed production and supply systems
Lack of mechanization	Tillage machines, zero-till planter and harvester
Poor transfer of technology	Innovative farmer's participatory approach

Some efforts have been made in the past for increasing productivity of pulses in rice fallow areas in respect of identification of suitable varieties, planting methods, foliar nutrition and plant protection. The rice fallow initiative builds on past successes, refining and packaging improved technologies to address different problems.

Choice of appropriate crops and varieties: Depending upon winter temperature, soil texture and moisture, selection of crops should be made. In eastern plains, small- seeded lentil varieties like 'WBL 77', 'KLS 218', 'PL 8', 'NM 1', and 'DPL 15' having resistance to rust are performing well. Chickpea varieties viz., 'Pusa 372', 'PG 186' and 'Udai' are recommended for this region. In central region, lentil and lathyrus are important crops; however, small seeded chickpea also has good prospects. The recommended chickpea varieties are 'JSC 55', 'JSC 56', 'JG 14', 'Vijay', 'JG 315', and 'SAKI 9516'. Grasspea (*lathyrus*) which is the most versatile and hardy crop both for north-east and central zone is being discouraged due its high ODAP content (neuro-toxin) and consequent ban on its trade. However, the newly developed varieties like ‘Ratan’, ‘Mahateora’ and ‘Prateek’ have quite low level of neurotoxin (ODAP). In lentil, small-seeded varieties perform better than large-seeded ones due to better contact with soil, less rotting and thus better plant stand.

In coastal region, powdery mildew is a deadly disease in urdbean and mungbean. Accordingly powdery mildew resistant varieties of urdbean like ‘LBG 17’, ‘LBG 602’ and ‘LBG 623’, and of mungbean ‘Pusa 9072’, ‘NARM-1’,‘-2’, and ‘-18’ have been developed. ‘LBG 17’ – the first powdery mildew resistant variety with yield potential of 1.5 t/ha has revolutionized urdbean cultivation in rice fallows of coastal peninsula. With appearance of mungbean yellow mosaic virus, variety ‘LBG 752’ is the most appropriate for its wide adoption. The recommended varieties of urdbean for normal planting (mid- November to mid- December) are: ‘LBG-402’, ‘LBG-611’, ‘LBG-22’, ‘LBG-648’, ‘LBG-685’, ‘LBG-645’, ‘LBG-709’ and ‘LBG-752’; whereas for late planting (second fortnight of December), the varieties like ‘LBG-22’, ‘LBG-645’, ‘LBG-685’ and ‘LBG-752’ are most appropriate. In mungbean, the recommended varieties for normal planting are ‘LGG-460’, ‘LGG-410’, ‘LGG-450’,’ LGG-407’ and ‘IM 96-3’.

Groundnut is appearing as a potential crop in rice fallows of Andhra Pradesh, Odisha, and north-eastern hill region. The recommended varieties are ‘Kadiri 4’, ‘Kadiri 6’, ‘TAG 24’, ‘Greshma’, ‘Rohini’, ‘Tripura 4’ and ‘Narayani’. In coastal Andhra Pradesh where sorghum has been introduced under limited irrigation, hybrid ‘Mahalaxmi 296’ is most promising.

Seed priming and optimum seed rate: Overnight soaking of seeds, referred as seed priming, hastens seed germination and establishment under relay cropping. Since all broadcast seeds do not establish good contact with soil, the seed germination is low. Therefore, adoption of 20-25% higher seed rate over the recommended rate ensures desired plant stand.

Foliar nutrition: Since application of fertilizers under relay cropping is not feasible, seed pelleting and foliar application of nutrients should be practiced. A large number of frontline demonstrations under All India Coordinated Research Project on Chickpea/ mungbean, urdbean, lentil, lathyrus, rajmash and pea (MULLaRP) showed that foliar application of 2% urea at flowering and pod formation significantly improved yields of chickpea under rainfed conditions by increasing leaf N content and making them photosynthetically more active (IIPR, 2007-08). Seed pelleting with micronutrients like Zn and Mo is also recommended as a part of nutrient management strategy in rice fallows.

Planting strategy: In rice fallows, planting is generally delayed. Under relay planting, seeds should be broadcast 2-5 days before harvest of rice. Zero-till seed-cum-fertilizer drill should be used wherever feasible when planting is done after harvest of rice. It is necessary to use short to medium maturing varieties of rice for timely planting of *rabi* crops.

Plant protection: Since post-emergence herbicides are not commercially available specially for crops like chickpea and lentil and inter-cultivation is difficult due to hard soil, hand pulling of weeds is the only option which should be done at an early stage. In the recent years, a post-emergence herbicide (imazethapyr @ 50 g/ha) has been found quite effective against seasonal grassy weeds in crops like groundnut, urdbean and mungbean. It should be applied at 3-4 leaf stage. Similarly, quizalofop can be used to check ratooning of rice stubbles which cause substantial moisture loss. Insect-pests and diseases should be promptly controlled. Seed dressing with fungicides like carbendazim should be done. Efforts should be made to choose disease-resistant varieties.

7. RESEARCH AND DEVELOPMENTAL EFFORTS

The rice fallows have a great potential for cultivation of short-duration pulses and oilseeds. However, very little effort has been made to efficiently utilize these new lands with appropriate technical and developmental back-up. Under All India Coordinated Research Project on MULLaRP, limited work on management aspects and development of short-duration and high-yielding varieties of lathyrus and lentil has been carried out in central zone. For coastal peninsula, high-yielding and disease-resistant (powdery mildew) varieties of urdbean and mungbean have been developed which led to significant increase in area and production particularly in Krishna-Cauvery delta. Rice fallows of eastern plains and north-east are almost untouched. Recently, a DST-sponsored project has been launched in Jharkhand to address the problem of rice fallow situations. Similar efforts are being made under the NFBSRA project of ICAR on mitigating abiotic stresses and enhancing resource use efficiency in pulses in rice fallows of eastern and southern India.

National Food Security Mission (NFSM), Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India has funded special projects to international institutes on rice fallows. During 2008-09 to 2011-12, ICRISAT implemented a NFSM-funded project on “Enhancing chickpea production in rainfed rice fallow land of Chhattisgarh and Madhya Pradesh” in partnership with NARS. Another project on “Enhancing lentil production for food, nutritional security and improved rural livelihood" was sanctioned to ICARDA in 2010 which is being operated in Assam, Bihar, Uttar Pradesh and West Bengal in collaboration with NARS. Similarly, a special project on "Enhancing grasspea production for safe human food, animal feed and sustainable rice-based production system in India" was also funded by NFSM to ICARDA, which is being implemented in the states of Bihar, Chhattisgarh, Uttar Pradesh and West Bengal. However, in these projects, varietal evaluation and seed production are the major activities while soil and crop management aspects have remained untouched. Earlier to these efforts, Department for International Development (DFID) and ICRISAT under a joint programme made efforts to introduce short-duration chickpea in rice fallows of Bangladesh and West Bengal. All these projects were launched in isolation in some specific areas without follow-up action, and thus did not show visible impact in the region.

8. SCOPE FOR UTILIZATION OF RICE FALLOWS

The potential districts for utilization of rice fallows for pulse cultivation suggested by the Expert Group on Pulses, DAC, MoA (2009) are given in Table 5. Special efforts are required in these districts to bring additional area under cultivation. It is expected that nearly 3.0 million hectare area of rice fallows can be brought under cultivation, which can provide about 1.5-2.0 million tonnes of additional foodgrain production.

Table 5. Potential area available in different districts for cultivation of pulses in rice fallows.

State	Potential area (m ha)	Districts
Chhattisgarh	0.88	Bilaspur, Dhamtari, Kanker, Jashpur, Raipur, Durg, Rajgarh, Kabirdham, Korba, Mahasamud and Rananadgaon
Madhya Pradesh	0.53	Annupur, Chhatarpur, Damoh, Dindori, Raisen, Jabalpur, Katni, Jhabua, Rewa, Satna, Shahdol, Seoni, Mandla, Narsingpur and Umeria
Odisha	0.37	Baleshwar, Dhenkanal, Sundergarh, Mayurbhanj, Kalahandi, Bolangir, Kheonjar, Puri and Cuttack
West Bengal	0.52	Bankura, Purulia, Medinapur, West Dinajpur, Malda, Jalpaiguri, Bardhaman and Birbhum
Assam	0.16	Marigaon, Naogaon, Lakhimpur, Kokrajhar, Bongaigaon, Nalbari, Kamrup, Barpeta, Darrang, Cachar, Goalaghat, Jorhat, Dibrugarh, Tinsukia and Sonitpur

9. RECOMMENDATIONS

A. Research and development issues

Disaggregated mapping of rice fallows: Satellite image data on rice fallows published in 2001 provide some preliminary information but are inadequate for sound planning for agricultural development in these regions. There is a need for disaggregated mapping of rice fallows with respect to soil health and rainfall pattern; cropping system, crop productivity, stability and production constraints; socio-economic indices like poverty, education, income, stray cattle menace and livelihood security; existing infrastructures and marketing so that region / site-specific programmes could be developed.

Consolidation of R&D activities: In the past, several agencies such as ICAR, DST, NFSM, National Rainfed Area Authority, ICRISAT and ICARDA carried out R&D activities in rice fallows of select districts and generated useful information. There is a need to critically examine the achievements, shortcomings and suggestions made for improvement in approaches and promotion of R&D efforts in other areas. An independent team consisting of scientists, development personnel and DAC representatives may review the progress made so far and bring out a document on future strategies.

Pilot projects: Pilot projects with holistic approach on rice fallows of different regions are needed to assess the potential of different crops and available technologies. These pilot projects will help in scaling-up the R&D efforts for extending in larger areas. There is a need for convergence of different programmes launched by the Govt. of India and other agencies with strong financial support.

Research gaps: Information on appropriate crops and varieties, soil health, water management, agro-techniques, pest management, mechanization etc. are scanty. There is need to identify major research gaps for each intervention through appropriate research projects. The proven research results will help in refining the need-based technologies for different ecosystems.

Systems approach: For productive utilization of rice fallows, a farming / cropping system approach should be followed. Along with food crops, livestock needs should also be addressed. Appropriate selection of rice varieties and management practices are imperative for successful introduction of a *rabi* crop. Construction of water harvesting reservoirs and farm ponds to provide come-up / life-saving irrigation would ensure success of *rabi* crops and improve their productivity.

Mechanization of field operations: Residual soil moisture in surface layer at the time of planting *rabi* crops is the major constraint in rice fallows. Relay cropping in standing rice is often practiced but with use of combine for rice harvesting, the option is now shifting for direct seeding using zero-till drill or turbo type Happy Seed drill which need to be designed for different situations. For harvesting and threshing, appropriate machines need to be designed and developed.

Scaling-up crop management practices: Tillage and plant population management, application of nutrients and weed management in *rabi* crops pose serious challenges in rice fallows. Early-maturing crop varieties, relay cropping, higher seed rate, seed priming, seed inoculation with *Rhizobium* culture, seed pelleting, mulching, foliar spray of nutrients etc. are recommended practices which need to be further refined and standardized for different ecosystems. Work on development of short-duration, high-yielding varieties, appropriate seeding techniques, water harvesting and recycling, post-emergence herbicides, biotic and abiotic stresses etc. need to be strengthened.

Crop-specific information on area expansion: Based on biophysical conditions, farm resources and market demand, likely coverage of area under each crop in different states / region need to be estimated. This would facilitate area expansion in phased manner by arranging critical inputs.

Periodic GIS mapping: In order to monitor impact of R&D efforts on area expansion in rice fallows under different crops, cropping systems and soil health, periodic monitoring through GIS is required.

B. Policy issues

It is evident that policy interventions will have large impact on utilization of rice fallows for pulses (chickpea, lentil, peas, lathyrus, mungbean and urdbean), oilseeds (groundnut, mustard, linseed) and other crops (sorghum / fodder crops), and adoption of new technologies by resource-poor farmers. About 30-40% of the area currently left fallow after rice can be converted into productive farm lands. About 3.0 million ha additional land under pulses and 1.0 million ha under oilseeds can be brought with appropriate policy interventions. Following points need due consideration:

Creation of community water reservoirs: Despite heavy rains during *kharif* season, soil moisture becomes the most critical limiting factor for raising second crop during winter as most of the runoff is wasted. It is, therefore, necessary to create farm pond and community water reservoirs in the area well supported by Government. This will serve as important source for life-saving and supplemental irrigation. Further, the loss of soil and plant nutrients from productive lands will be reduced.

Quality seeds: Timely availability of quality seeds is often a major constraint for delayed planting and poor yields. Hence, community-based seed production programmes need to be launched with appropriate processing and storage facilities. The national and state seed corporations should strengthen their activities in these areas.

Ensuring timely availability of other critical inputs: Traditionally, the winter crops on residual soil moisture are grown using local varieties without application of plant nutrients, biofertilizers, fungicides and other agro-chemicals due to their non-availability. Since crop productivity is the driver for area expansion, which in turn is influenced by better crop management, emphasis needs to be placed on timely availability of all critical inputs.

Rural credit: Poor socio-economic conditions and purchasing power compel farmers either to skip second crop after rice or resort to no input use. Therefore, subsidies on farm inputs, credit and crop insurance schemes should be implemented.

Marketing infrastructure: Marketing plays a key role in enthusing farmers for crop production. Well organized marketing and processing of farm produce need attention.

Protection from stray cattle: Blue bull and other stray cattle cause heavy damage to pulses and thus discourage farmers to grow winter crops. Appropriate policies are needed to tackle this menace. To avoid crop damage by stray cattle, open grazing lands at panchayat level should be earmarked. These activities should be the part of state level planning.

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List of Participants

1. Prof. R.B. Singh, President, NAAS, New Delhi
2. Prof. Anwar Alam, Secretary, NAAS, New Delhi
3. Dr. Masood Ali, Ex-Director, IIPR, Kanpur
4. Dr. A. Sarker, Regional Coordinator, South Asia and China, ICARDA, NASC Complex, New Delhi
5. Dr. Sanjeev Gupta, Project Coordinator (MULLaRP), IIPR, Kanpur
6. Shri S.K. Choudhary, Jt. Director of Agriculture, Govt. of Bihar, Patna
7. Dr. H.K. Dikshit, Principal Scientist, IARI, New Delhi
8. Dr. B. Gangwar, Project Director, Project Directorate of Farming Systems Research, Modipuram
9. Dr. P.K. Ghosh, Director, IGFRI, Jhansi
10. Dr. Dinesh Kumar, Principal Scientist, IARI, New Delhi
11. Sh. D.P. Malik, Additional Commissioner, DAC, Min. of Agric., New Delhi
12. Dr. N. Nadarajan, Director, IIPR, Kanpur
13. Dr. Rajendra Prasad, Ex-ICAR National Professor, C 309, Vardhan Apartments, Mayor Vihar Ext. Phase 1, New Delhi
14. Dr. Y. Koteshwara Rao, Pr. Scientist, ANGRAU, Agril. Res. Station, Guntur, AP
15. Dr. D.A. Sarnaik, Director of Research, IGKV, Raipur
16. Dr. B.B. Singh, Assistant Director General (O&P), ICAR, Krishi Bhavan, New Delhi
17. Dr. K.P. Singh, Principal Scientist, CIAE, Bhopal
18. Dr. A.K. Vyas, Head, Division of Agronomy, IARI, New Delhi
19. Dr. D.K. Yadav, Principal Scientist, IARI, New Delhi

Note: The designations and affiliations of the participants are as on the date of BSS.

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