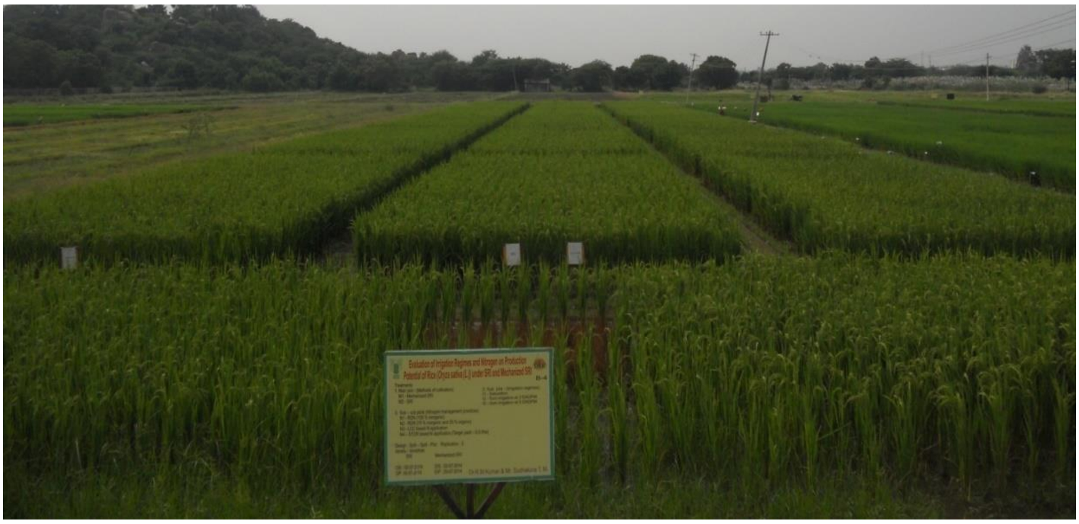
Indian Council of Agricultural Research

Proforma for Certifying a Technology

Modified Leaf Colour Chart (LCC)



Submitted by

Dr. R. Mahender Kumar

Principal Scientist & Head, Agronomy

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Rajendranagar, Hyderabad-500030, India

Agronomy ICAR-IIRR Technology 4; Modified Leaf colour chart for enhancing the Irrigated rice production and Nitrogen use efficiency

Item	
1. Name of the product/technology (as defined above)	Modified Leaf colour chart for enhancing the Irrigated rice production and Nitrogen use efficiency
2. Name and address of the Institute	ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad – 500030, Telangana
3. Institution(s) responsible for developing/evaluating/identifying including collaborators, if any	ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad – 500030, Telangana
4. Source of product/technology (Research Project/Student Research/Any other ad-hoc research study)	Student Research
5. Period of development/evaluation/validation	2013-2018
6. Developers (Lead and Associates)	Dr. R. Mahender Kumar
7. Summary of the product/technology (maximum of 200 words)	Application of N based on LCC registered significantly higher growth parameters, root growth characteristics, yield attributes, yield, nutrient uptake, P and K P and water productivity which were comparable with STCR based nitrogen management practice. The net energy, energy use efficiency, energy productivity and energy intensity in economic terms recorded significantly higher with SRI. Irrigation at 3 DADPW recorded significantly higher energy use efficiency, energy productivity and energy intensity in economic terms which were at par with saturation treatment. Nitrogen application based on LCC recorded significantly higher energy use efficiency, energy productivity and energy intensity in economic terms as compared to other nitrogen management practices.
8. Is it a new technology? (Yes/No). If no, prove the details of the technology modified	Yes
9. IPR involved, if any (Patent/Copyright/Industrial Design Registration/Variety/Germplasm registration). Provide Filed/Granted number	Yes

10. Validation procedure followed (within Institute, collaborators, multilocation/multi-site testing)	Within institute
11. Brief description of research output/technology	• Leaf colour chart (LCC) measures the green colour intensity of rice leaves. It consisted of high-quality plastic with strips of green colour shades ranging from light yellowish green (1) to dark green (5) colour strips fabricated with veins resembling those of rice leaves • 20-30 % of applied Urea fertilizer can be saved for rice cultivation • Reduces the N20 accumulation in irrigation water

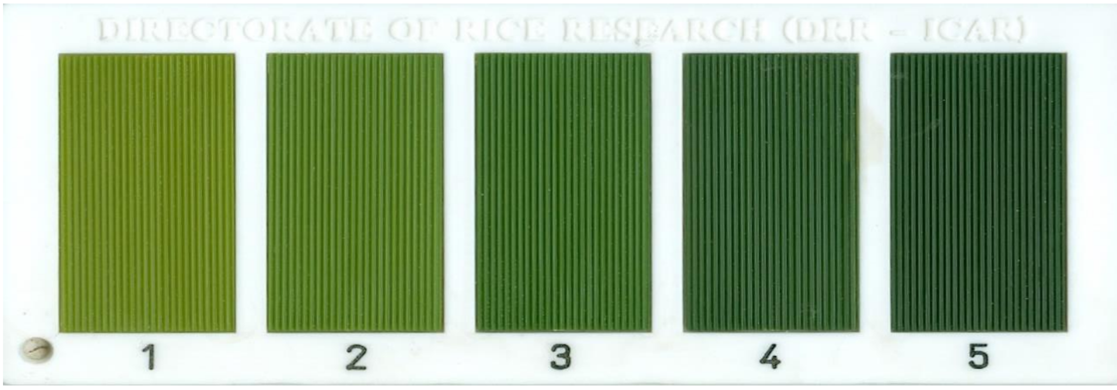
a. **Objective**

- to evaluate Modified Leaf Color Chart potential for higher grain yield.

b. **Methodology**

The colour of the single leaf (topmost fully expanded) was measured by holding the leaf colour chart vertically and placing the middle part of leaf, 1 cm in front of colour strip for comparison. During measurement, the leaf being measured was shaded with the body to avoid interference by sunlight intensity. Ten readings were taken for each plot and average was computed by rounding off to the nearest 0.5 to determine the need for nitrogen top dressing.

In LCC based nitrogen management treatment, the LCC values were recorded as per standard procedure (IRRI, 1996) at weekly interval starting from 14 DAT to flowering. Whenever the LCC values were found to be below the fixed critical level of three, recommended quantity of nitrogen was applied @ 25 kg ha-1and the basal dose of nitrogen was applied @ 30 kg ha-1.



Leaf Colour Chart (LCC) – Indian Institute of Rice Research

c. **Yield attributers & Yield**

Application of nitrogen based on LCC resulted in significantly higher plant height, number of tillers m-2, leaf area hill-1, LAI, LAD, dry matter production and partitioning and CGR at all the growth stages which were at par with STCR based nitrogen application. RGR was significantly higher in nitrogen application based on LCC between 0-30 DAT which was comparable with STCR based nitrogen application and there was no significant difference in other growth stages. The regression between dry matter production vs. plant height, number of tillers m-2, LAI and nitrogen uptake was positive and linear, these parameters accounted for 97.0, 98.3, 93.5 and 93.6 % of explained total variability in dry matter production, respectively. The lowest values were recorded with RDN through inorganic.

Nitrogen application based on LCC recorded significantly higher irrigation water productivity and water productivity which was comparable with nitrogen application based on STCR management practice. The lowest values were registered with RDN through inorganic. Among nitrogen management practices, LCC based nitrogen management recorded significantly higher N and K uptake at all the crop growth stages, grain and straw. In case of P, uptake was higher with RDN (75 % inorganic and 25 % organic) at all the crop growth stages, grain and straw except at 30 DAT. At 30 DAT the nitrogen application based on LCC recorded significantly higher P uptake. The lowest N, P and K uptake registered with RDN through inorganic at all the growth stages. The highest cost of cultivation was recorded with RDN (75 % inorganic and 25 % organic) management practice and lowest was with RDN through inorganic only. Gross returns, net returns and B:C ratio were significantly higher with nitrogen application based on LCC and was comparable with STCR based nitrogen application. The lowest net returns and B:C ratio was recorded with RDN (75 % inorganic and 25 % organic) management practice. f. **Passport data of the product/ technology** Along with the instiutional experiments, it also evaluated under various AICRIP cultural management trials.	
12. Details of relevant data generated during the development/validation	Attached

- The highest cost of cultivation was recorded with RDN (75 % inorganic and 25 % organic) management practice and lowest was with RDN through inorganic only. Gross returns, net returns and B:C ratio were significantly higher with nitrogen application based on LCC and was comparable with STCR based nitrogen application. The lowest net returns and B:C ratio was recorded with RDN (75 % inorganic and 25 % organic) management practice.

Table . Grain, straw yield (kg ha^{-1}) and harvest index (%) of rice as influenced by planting methods, irrigation regimes and nitrogen management practices during *kharif* 2013, 2014 and pooled means

Treatments	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest Index (%)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
Planting methods (M)									
M_1 – MSRI	5706	5903	5804	6758	6950	6854	45.74	45.90	45.82
M_2 – SRI	6010	6168	6089	7095	7265	7180	45.87	45.91	45.89
S.Em±	37	39	38	37	34	31	0.30	0.25	0.27
C.D. at 5%	224	235	230	226	207	190	NS	NS	NS
Irrigation regimes (I)									
I_1 – Saturation	6123	6315	6219	7118	7364	7241	46.24	46.17	46.20
I_2 – 3 DADPW	6036	6219	6127	7119	7322	7221	45.89	45.92	45.91
I_3 – 5 DADPW	5414	5573	5494	6541	6635	6588	45.28	45.63	45.45
S.Em.±	57	63	60	73	51	29	0.37	0.17	0.22
C.D. at 5%	186	207	196	238	165	96	NS	NS	NS
Nitrogen management practices (N)									
N_1 – 100 % RDN (inorganic)	5574	5766	5670	6656	6849	6753	45.55	45.69	45.62
N_2 – 75% inorganic + 25% organic	5847	6033	5940	6891	7076	6983	45.89	45.99	45.94
N_3 – LCC based nitrogen	6063	6238	6150	7080	7213	7146	46.13	46.38	46.25
N_4 – STCR targeted yield 6.5 t ha^{-1}	5947	6105	6026	7078	7292	7185	45.65	45.57	45.61
S.Em.±	66	68	66	64	59	41	0.33	0.27	0.25
C.D. at 5%	187	192	188	182	167	115	NS	NS	NS
Interactions	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	6.76	6.76	6.71	5.91	5.51	4.45	5.04	4.51	4.34
General Mean	5858	6036	5947	6926	7107	7017	45.81	45.91	45.86

Indian Journal of Agronomy **46** (1) : 81–88 (March 2001)

Nitrogen management through soil and plant analysis development and leaf colour charts in different groups of rice (*Oryza sativa*) varieties grown on Vertisols of Deccan plateau

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Received : October 1999

ABSTRACT

A field experiment was conducted during the rainy *(kharif)* and winter *(rabi)* seasons of 1997–98 at Rajendranagar, Hyderabad, to compare the N-use efficiency of SPAD-502 (soil and plant analysis development) chlorophyll meter-based N fertilizer management with recommended fixed schedule of N fertilizer splits applied at critical growth stages and to assess the relation of SPAD and leaf colour chart (LCC) readings recorded at critical crop-growth stages with grain of rice (*Oryza sativa* L.). In SPAD-based N management, the N was applied when SPAD value decreased below 35 of fixed value and the amount applied as per the stage of the crop. Hybrids recorded higher grain yield of 4.85 and 5.16 tonnes/ha during rainy and winter season respectively than scented and high-yielding varieties respectively. The SPAD–N application gave significantly higher grain yield than 135 kg N/ha during rainy season, while on par with that in winter. The agronomic efficiency (Δ kg grain/Δ kg N) and partial factor productivity (kg grain/unit N) was higher for SPAD-based N application than 135 and 90 kg N/ha. The SPAD and leaf colour chart values recorded at critical stages were significantly higher with application of N. These values showed positive correlation (0.78 to 0.85 in rainy season and 0.78 to 0.90 in winter season) in both seasons at all crop-growth stages, indicating use of LCC as a tool for N top-dressing. Thus increased N fertilizer efficiency at high yield levels is possible in hybrids and high-yielding varieties using a chlorophyll meter and LCC to monitor leaf N status and guide fertilize N timing in irrigated rice. These methods not only reduced N requirement but also improved congruence of N supply and crop demand than fixed timing of N application treatment.

Key words : Nitrogen management, SPAD meter, LCC, Cultivars, Hydrids, Rice

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SATSA Mukhapatra - Annual Technical Issue 20 : 2016 ISSN 0971-975X Invited Paper

Efficient Nutrient Management Practices for Sustaining Soil Health and Improving Rice Productivity

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(Received : January 09, 2016; Revised: January 15, 2016; Accepted: February 20, 2016)

ABSTRACT

Being the most important staple food crop, rice plays a vital role in food security of many countries including India. Rice production needs to be enhanced by 2.0-2.5 million tonnes year^{-1} to meet the growing demand of burgeoning population in next 15-20 years. Healthy soils play an important role in maintaining sufficient biological activity, improving root growth, providing sufficient nutrients to crop plants and sustaining crop productivity. The present paper deals with different factors relating to integrated nutrient management, various options, cropping systems, conservation agriculture practices, and their effect on soil health and productivity of rice and rice-based cropping systems. Efficient nutrient management practices lead to balanced nutrition and maintain soil health for sustaining productivity of any cropping system.

Key words : Cropping system, Nutrient management, Rice productivity, Soil health.

Introduction :

Rice is the most important staple food crop for more than 60% of the global population. India ranks first in rice area covering about 45 million hectares (m ha) and second in rice production, after China, with about 106 million tonnes (mt). Increased use of fertilisers was responsible for higher crop yields in the Green Revolution era contributing as much as 50% to yield growth in Asia (Hopper, 1993). Nutrient management is most important for any crop to achieve maximum / optimum yields and efficient practices obviously help in achieving target yields without damaging soil health. Intensive rice farming after Green Revolution has resulted in excessive or indiscriminate use of chemical fertilisers and pesticides, causing ultimate reduction in productivity of soils by affecting soil health in terms of physical, chemical and biological properties. The left over chemical residues become toxic to plants. Hence, it is important to apply agro-chemicals very judiciously to get best yields without affecting the soil health. Emphasis should be given towards reducing the use of chemical fertilisers and improving their use efficiency. Increasing nutrient use efficiency (NUE) has been gaining more attention with the rising fertiliser costs and growing concerns over environmental impairment.

Soil health has been defined by Doran and Zeiss (2000) as 'the capacity of soil to function as a vital living system, within ecosystem and land use boundaries, to sustain plant and animal production, maintain or enhance water and air quality, and promote plant and animal health'. Healthy soil functions optimally through balanced interactions amongst its biological, physico-chemical and mineral components. Healthy soils play an important

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Rice Agronomy: Towards Improving Productivity and Sustaining Soil Health

R. Mahender Kumar, M. D. Tuti, B. Sreedevi, K. Surekha and V. Ravindra Babu*

(Received : January 23, 2016; Revised: January 31, 2016; Accepted: February 20, 2016)

ABSTRACT

Soil quality is considered as a key element of sustainable agriculture. Several experiments have been conducted across the states of India to assess different crop establishment methods and management practices to enhance the productivity and to sustain the soil fertility. There is a need to manage the variability in indigenous nutrient supplies for sustaining the productivity under different rice ecosystems. The genetic potential of any variety can be realized only when the crop management practices are optimized in presence of favourable climatic, edaphic and biotic environment. The prime objective of using improved crop and soil management practices is to help sustain the productivity of high potential lands and to exploit the potential of underutilized lands through improved land preparation, crop establishment, weed management, integrated nutrient management and conservation agriculture.

Key words : Crop establishment methods, Rice productivity, Soil health.

Introduction :

Rice (*Oryza sativa* L.) is one of the most important staple food crops in the world. In Asia, more than two billion people are getting 60-70% of their energy requirement from rice and its derived products. Among the rice growing countries, India has the largest area of 42.27 million hectares (m ha) and is the second largest in rice production, producing 105.24 million tonnes (mt) of rice, next to China (144 mt). With an average productivity of 2.49 t ha^{-1}, India is still below the world's average yield of 4.36 t ha^{-1} (FAOSTAT, 2014). However, rice continues to hold the key to sustain food security of the country. Future rice production targets have to be achieved exclusively through yield improvement, because rice areas are likely to stabilize or even register negative growth. Soil quality is considered as a key element of sustainable agriculture. Although sustainability issues are much broader than soil quality, the strong emphasis needs to be given on maintaining the natural-resource base. High growth rate in rice productivity can be achieved through: (a) increasing adoption of high-yielding varieties (HYVs) in rainfed systems, (b) increasing consumption of fertilizer nutrients, (c) making access to and timely availability of quality seeds (largely facilitated through farmer-to-farmer spread from frontline demonstration sites), and (d) appropriate adoption of production and protection practices. Maintenance of native soil fertility in the intensively cultivated regions of the country is one of the pre-conditions of maintaining and improving the current crop yield levels. Intensive cropping systems remove a substantial quantity of plant nutrients from soil

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Agronomic Manipulations for Climate-Resilient Rice Production in India

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ABSTRACT

Grain yield of rice can decline to the extent of 10% for each 1°C increase in growing season minimum temperature above 32°C, which leads to severe water shortage due to climate change, causing about 20% net decline in rice yield in India. Several experiments were conducted in rice to reduce water requirement and enhance nutrient use efficiency, in turn mitigating the effect of climate change under All India Co-ordinated Rice Improvement Programme (AICRIP) and at ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad. Nitrogen-efficient rice cultivars, fertilizer scheduling using different means, improved water management techniques and crop establishment methods were developed towards mitigation and adaptation of changing climate scenario. Results across 19 locations under AICRIP revealed that site-specific nutrient management (SSNM) through Nutrient Expert® would be able to enhance grain yield and nutrient use efficiency over recommended dose of fertilizers (RDF). Leaf colour chart (LCC)-based N application in irrigated rice indicated grain yield increments by 8.47, 6.28 and 4.76% in LCC, soil test crop response (STCR) and recommended dose of N (RDN: 75% inorganic and 25% organic)-based management practices, compared with RDN (100% inorganic), respectively. The System of Rice Intensification (SRI) recorded 16-23% higher grain yield with 18-32% water saving, compared with normal transplanting. Alternate wetting and drying (AWD) and saturation could record water saving by 33.0 and 19.6% in *kharif* and 36.3 and 31.2% in *rabi*, respectively, compared with continuous submergence. Irrigating rice field at 5-day interval reduced seasonal methane (CH_4) emission by 54 and 68%, compared with continuously submergence, without any yield decline (5.14 and 5.82 t ha^{-1}) during *kharif* and *rabi*, respectively. However, there is a need to adopt suitable management as well as better crop establishment methods coupled with proper water management practices to mitigate the adverse effect of changing climate and to enhance water productivity as well as total factor productivity.

Key words: Climate change, Climate-resilient rice, Crop establishment methods, Nutrient use efficiency, Water use efficiency.

Introduction :

Rice is the staple food for more than half of the world's population and plays a pivotal role in food security of many countries. More than 90% of the global production and consumption of rice is in

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Productivity of rice as influenced by irrigation regimes and nitrogen management practices under SRI

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Received: May, 2017; Revised accepted: July, 2017

ABSTRACT

A field experiment was conducted on a clay loam soil at Indian Institute of Rice Research (IIRR), Rajendranagar, Hyderabad, Telangana during the kharif seasons of 2013 and 2014 to studay the effect of irrigation regimes and nitrogen management on rice under SRI. The Varadhan (DRR Dhan 36) variety was used in field experiment. The results revealed that the system of rice intensification proved significantly superior in terms of growth and yield parameters such as plant height, number of tillers, leaf area index, number panicles^{-1}, filled grains panicle^{-1}, test weight, grain yield and straw yield as compared to mechanized system of rice intensification. Irrigation maintained at saturation level produced significantly higher growth, yield parameters and yield which were comparable with irrigation at 3 DADPW. Application of nitrogen based on leaf colour chart registered significantly higher growth, yield parameters and yield which were at par with soil test crop response based nitrogen management practice but both these treatments were significantly superior over the RDN - 75 % inorganic and 25 % organic and RDN - 100 % through inorganic management practices.

Key words: Mechanized system of rice intensification, leaf colour chart, Productiviy, regression

INTRODUCTION

Traditional planting has been the most important and common method of crop establishment practice under irrigated lowland rice ecosystems in tropical Asia. In irrigated lowland rice which not only consumes more water but also causes wastage of water resulting in degradation of land. In recent years to tackle this problem, many methods of cultivation have been developed and one among them is System of Rice Intensification (SRI). SRI is a holistic agro ecological crop management technique seeking alternatives to the conventional high-input agriculture through effective integration of crop, soil, water and nutrient management. The mechanical transplanting of rice has been considered the most promising option, as it saves labour, ensures timely transplanting and attains optimum plant density that contributes to high productivity. Overexploitation of ground water during recent decades has caused serious problems in South Asia (Perveen *et al*, 2012) which is affecting rice growing areas. Further, they observed that groundwater tables have dropped on an average by about 1 m y^{-1} in southern India, where flooded rice is the dominant cropping system. Therefore, rice could face a threat due to water shortages and hence, there is need to develop and adopt water saving methods in rice cultivation so that production and productivity levels are elevated despite the looming water crisis. Among nutrients, Nitrogen is the most important limiting element in rice growth (Jayanthi *et al.*, 2007a). Limitation of nitrogen in any growth phase of the plant growth causes reduction in yield. Improved understanding of the availability of nitrogen from the native organic nitrogen sources and the fate of added nitrogen fertilizer should aid in developing innovative nitrogen management practices and an increase in the efficiency of fertilizer. Keeping these points in view the field experiment was conducted to study effect of irrigation regimes and nitrogen management on productivity of rice under SRI.

Materials and Methods

A field experiment was conducted on a clay loam soil at Indian Institute of Rice Research (IIRR) formerly Directorate of Rice Research (DRR), Rajendranagar, Hyderabad, Telangana during the *kharif* seasons of 2013 and 2014. The variety was used Varadhan (DRR Dhan 36) is a derivative of indica / japonica cross with mid early duration that matures in 120-125 days. The treatments consisted of two planting methods (Mechanized system of rice intensification (MSRI) and system of rice

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Innovative strategies and smart skills for dissemination of Climate-Resilient Rice Production technologies to farmers

Amtul Waris, K Surekha and R Mahender Kumar

Abstract
In the present study a combination of *experiential, reinforcement and integrative* extension methods were employed to disseminate selected climate-resilient rice production technologies to farmers (150) in Devunigadda, Yellammatanda and Korra Tanda villages of Telangana, India. The *experiential* methods (method demonstrations, training, video film, exposure visits) allow the learner to gain experience with or to feel the information presented. *Reinforcement* methods (fact sheet, poster, pamphlet) were used to provide informational, emotional, or social support for the learner to facilitate learning and enhance or maintain the motivation to continue in the learning process. *Integrative* methods (discussion groups, personal visit, meeting) were utilized to provide opportunities for learners to merge new information with their existing knowledge. Selected climate-resilient rice production technologies i.e., use of green manure crop, Integrated Nutrient Management (INM), use of Leaf Color Chart (LCC) for optimizing nutrient use, setting up of vermi-compost units were demonstrated on the farmer's fields during kharif 2016. Nutrient-smart technologies like, green manure crop was grown for 45-60 days on farmers' fields in Devunigadda village and was incorporated into the soil before puddling. Farmers expressed satisfaction over the use of green manure and vermi compost along with zinc and balanced chemical fertilizers in reclaiming problem soils. The yield improvement ranged from 22.1 to 36.6% due to INM practice. Water smart interventions that improve water use efficiency were demonstrated through creating awareness on System of Rice Intensification (SRI) techniques. Skill training on use of drum seeder was undertaken in two villages as an energy smart technology. These Climate Smart interventions aim to sustainably increase productivity and income, build resilience to climate change, reduce greenhouse gas emissions and enhance achievement of food security goals. The farmers were thus motivated to adopt these climate-resilient rice production technologies to achieve food and livelihood security.

Keywords: Innovative strategies, smart skills, Resilient Rice Production, farmers

Introduction

Agricultural production remains the main source of income for most rural communities, adaptation of the agricultural sector to the adverse effects of climate change will be imperative for protecting and improving the livelihoods of the poor and ensuring food security (FAO, 2012a). Climate-smart crop production is a sustainable crop production system to address climate change and it is increasingly being reiterated that, increasing food production alone may not enable rural people to come out of poverty. It is essentially important to build the capacity of smallholders to harness the power of collectives, manage the natural resources, acquire financial literacy, engage in profitable enterprises and innovate and add value to their produce. All of these form important elements of sustainable agricultural development strategy.

There are a large variety of methods that can be used to deliver the Extension education programs or disseminate information and the choice depends on the needs, interests and purpose of the educational program. The choice of best methods for teaching new information (experiential), reinforcing and motivating learning, as well as expanding existing information determine the successful implementation of interventions.

Experiential These methods allow the audience to gain experience with the information being taught. It involves hands-on activities that utilize the senses. These methods are excellent for teaching new information.

Reinforcement: These methods reinforce learning and provide motivation for continued learning. They also reinforce information that has already been taught or that which learners already know.

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REVIEW ARTICLE https://doi.org/10.58297/VZZH6068

Efficient Nitrogen Management Technologies for Sustainable Rice Production

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Abstract

The use of nitrogen (N) fertilizers in rice fields as a source of nutrition is the major source of emission of nitrous oxide (N_2O). Two key factors which control the flux of N_2O at the field level are the amount of N supplied and the efficiency at which it is absorbed by plants. To reduce the N_2O emissions, optimum N fertilizer application (in terms of input rate and time of application) and ideal fertilizer selection are crucial. Optimizing N-use efficiency (NUE) is crucial to sustain productivity and profitability. Depending on edaphic and climatic conditions, improved N management can dramatically cut greenhouse gases (GHGs) emissions. Producers must ensure that the kind, rate, and time of N application do not result in substantial losses owing to volatilization, leaching, or denitrification. Adoption of best nitrogen management practices like deep placement of urea, use of nitrification inhibitors, urease inhibitors, and slow-release nitrogen fertilizers will reduce the N loss and increase NUE. The goal of this review is to discuss in detail the various technologies that have been developed and refined to improve NUE and protect the environment.

Keywords: Nitrogen, Nitrification inhibitor, Urease inhibitor, Slow-release fertilizer, Brown manuring, LCC, GreenSeeker, SPAD

Introduction

Fertilizers boost agricultural productivity and encourage crop CO_2 uptake and decrease the need to cultivate new land (deforestation), resulting in fewer GHG emissions as a result of land use change. Nitrogen (N) is the most important element for the overall growth and development of rice plants (Subramanian *et al.,* 2020). The atmospheric N is not readily available to rice plants despite its high abundance in the air (around 79%). The proportion of fertilizer N in the total N input for crop production in India is increasing since the advent of the Green Revolution in the mid-1960s, but NUE has declined from 48 to 35% in 2018. There is a limited opportunity to achieve significant yield gains by applying more fertilizer N. Although optimal fertilizer use on agricultural crops reduces soil erosion, repeated applications of high N fertilizer doses may cause soil acidity, a negative soil health trait (Nayak *et al.,* 2020). Site-specific management strategies based on the principles of synchronizing crop N demand with N supply from all sources, including soil and fertilizer, have the potential to ensure high yields while also preserving soil health (Vijayakumar *et al.,* 2021). Soil organic matter (SOM) is the repository for soil N. Balanced nutrient application and integrated nutrient management using organic manures and mineral fertilizers also contributed to the preservation and improvement of soil health (Nayak *et al.,* 2020). Thus, fertilizer N, when applied in a balanced proportion to other nutrients and in conjunction with organic manures, if available to the farmer, maintains or improves soil health rather than being detrimental (Nayak *et al.,* 2022). The good soil structure improves NUE and reduces N_2O losses. The challenge ahead is to manage N fertilizers in such a way that not only food demands are met continuously, but soil and environment remain healthy to support adequate food production with minimal environmental impact (Gobinath *et al.,* 2021).

Declaration: I/we hereby undertake that the above information is correct. All scientists in the development of this research output have been included in the list of associates. The research output does not involve any third party IPR.

1. Name and signature of all the developers

Name	Developer / co-developer / Collaborator	Signature
Dr. R.Mahender Kumar	Developer	
Dr. B.Sreedevi	Co-developer	
Dr. Ch. Padmavathi	Co-developer	
Dr. M.B.B. Prasad Babu	Co-developer	
Dr. Mangal ldeep Tuti	Co-developer	
Dr. Brajendra	Co-developer	
Dr. K. Surekha	Co-developer	
Dr. Raghuveer Rao	Co-developer	
Dr. V. Manasa	Co-developer	
Dr. T. Sudhakara	Co-developer	
Dr. D. Srinivas	Co-developer	

2. Recommendations of the Head of Division

3. Recommendations of ITMC/PME

4. Recommendations o DIRECTOR

5. Recommendations of SMD