CALIBRATION OF SOIL TEST, FERTILIZER DOSE AND CROP YIELD WITH AND WITHOUT FYM FOR HYBRID RICE UNDER SRI IN *VERTISOL* OF CHHATTISGARH PLAIN

M.Sc. (Ag.) THESIS

by

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DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY
COLLEGE OF AGRICULTURE
INDIRA GANDHI KRISHI VISHWAVIDYALAYA
RAIPUR (C.G.)

2019

CALIBRATION OF SOIL TEST, FERTILIZER DOSE AND CROP YIELD WITH AND WITHOUT FYM FOR HYBRID RICE UNDER SRI IN *VERTISOL* OF CHHATTISGARH PLAIN

Thesis

Submitted to the

Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.)

by

Anurag Gupta

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Master of Science

In

Agriculture
(SOIL SCIENCE AND AGRICULTURAL CHEMISTRY)

Roll No. 20171827435 **ID No. 120117225**

JULY 2019

CERTIFICATE –I

This is to certify that the thesis entitled**"Calibration of soil test, fertilizer dose and crop yield with and without FYM for hybrid rice under SRI in *Vertisol* of Chhattisgarh plain**" submitted in partial fulfillment of the degree of **Master of Science in Agriculture** of the Indira Gandhi KrishiVishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Anurag Gupta** under my guidance and supervision. The subject of the thesis has been approved by student's Advisory Committee and Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or certificate course. All the assistance and help received during the course of the investigations have been duly acknowledged.

Chairman

Date: 23.07.2019

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman (Shri Rakesh Banwasi) __________

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Member (Dr.H.L. Sonboir) __________

Member (Dr. M.L. Lakhera) __________ 23/7/2019

CERTIFICATE - II

This is to certify that the thesis entitled **"Calibration of soil test, fertilizer dose and crop yield with and without FYM for hybrid rice under SRI in *Vertisol* of Chhattisgarh plain''** submitted by **Mr. Anurag Gupta** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture** in the Department of Soil Science and agricultural chemistry has been approved by external examiner and student's Advisory Committee after oral examination .

Signature External Examiner

Place: Raipur

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Major Advisor ______________________

Head of the Department / Section ______________________

Dean / Faculty Dean ______________________

Approved / not approved

Director of instructions ______________________

ACKNOWLEGEMENT

Firstly, I am grateful to my parents for their sacrifices, tolerant impatient pains for me to come into the existence, and to bring up, for the sake of me, unknown how many hard works they did. I bow down to touch of their feet forever. Then, I bow to Almighty "GOD" who keeps ever burning before my vagrant steps the kindly light of hopes and always showered blessing on me without who seedless benevolence and blessing this tedious task could not be accomplished.

I with extreme pleasure take this opportunity to express my profound sense of reverence and deep gratitude to ***Shri Rakesh Banwasi****, Scientist, Department of Soil Science and Agricultural Chemistry &Chairman of my Advisory Committee for his ceaseless encouragement, incessant help, constructive and noble guidance and critical suggestions during the course of investigation and preparation of this manuscript.*

I feel immense pleasure in expressing my heartiest thank and deep sense of gratitude to my co- advisor Dr.L.K.Srivastava, Senior Scientist, Department of Soil Science and Agricultural Chemistry for his enduring interest, kind attitude, scholastic guidance, constant supervision and patience in leading my path to achieve the destination during the entire move despite his heavy schedule of work.

I extend my heartiest thanks to members of my advisory committee Dr.H.L. Sonboir, Senior Scientist, Department of Agronomy, Dr.M.L.Lakhera, Professor, Department of Agricultural Statistics and Social Science, IGKV, Raipur for their sincere advice, critical suggestion and kind help during the period of investigation.

My sincere thanks are due to ***Dr. K. Tedia****, Professor and Head, Department of Soil Science and Agricultural Chemistry for providing me research facilities, extremely useful help and valuable suggestion during my course of research work.*

I am highly obliged to Hon'ble Vice-Chancellor Dr. S. K. Patil, Dr. R. K. Bajpai, Director Research Services, Dr. S. S. Rao, Dean, College of Agriculture, Dr. G.K. Shrivastava, Dean Student Welfare and Dr. M.P. Thakur Director of Instruction, IGKV, Raipur for providing necessary facilities to conduct the investigation.

I feel honored to express my deep sense of gratitude to Dr. V. N. Mishra, Professor and Shri Gaurav Jatav, Scientist, Department of Soil Science and Agricultural Chemistry, College of Agriculture, IGKV Raipur for the timely help, encouragement anduseful suggestions during the course of this investigation.

I am also grateful to all the esteemed teacher Dr.K.K. Sahu, Dr.R.N. Singh, Dr.Alok Tiwari, Dr.S.S. Porte, Dr.Vinay Samadhiya Shri Vinay Bachkaiya of Department of Soil Science and Agricultural Chemistry, College of Agriculture, IGKV Raipur for their regular help and encouragement.

I also wish to express my gratitude to non-teaching staff of Department of Soil Science and Agricultural Chemistry, College of Agriculture, IGKV Raipur for their help and cooperation. I would like to appreciate the cooperation extended by Basant Bhaiya, Okesh Bhaiya, Fatte Bhaiya, Tarun Bhaiya, Ramesh Bhaiya, Parmanand Bhaiya and field labours.

I also wish to express gratitude towards all my seniors specially Anusuiya mam, Bindiya mam, Neha mam, Vivek sir, Himanshu sir and loving juniors for their constant encouragement and cheerful company.

I would like to give special thanks to my classmates Uttam, Bhumika, Priyanka, Ritesh, Geeteshwar, Stanley for their constant support and encouragement during the tenure of whole M.Sc. programme.

I would like to express my sincere gratitude to Dr. M. Pandey (Librarian, Nehru Library, Raipur) for giving me their kind help during my present study.

At last but not least, I would like to convey my cordial thanks to all unmensioned persons who have directly or indirectly helped me to reach to this level in my life.

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LIST OF ABBREVIATIONS

@	At the rate of
S.R.I.	System of rice intensification
CG	Chhattisgarh
Cm	Centimeter
^{0}C	Degree Celsius
et al.	and co-worker/and others
EC	Electrical Conductivity
Fig.	Figure
FYM	Farm yard manure
g	Gram
ha^{-1}	Per hectare
i.e.	That is
kg	Kilogram
K	Potassium
m	Meter
mm	millimeter
Mt	Million tonne
Wt.	Weight
N	Nitrogen
OC	Organic carbon
pH	Logarithm of the reciprocal of the H^+ ion activity
ppm	Parts per million
P	Phosphorus
%	Per cent
q	Quintal
RDN	Recommended dose of nitrogen
RDF	Recommended dose of fertilizer
RH	Relative humidity
S. No.	Serial number
T	Tonne
Viz.	That is to say / in other words

THESIS ABSTRACT

a) Title of the Thesis:	Calibration of soil test, fertilizer dose and crop yield with and without FYM for hybrid rice under SRI in *Vertisol* of Chhattisgarh plain
b) Full Name of the Student:	Anurag Gupta
c) Major Subject	Soil Science and agricultural chemistry
d) Name and Address of the: Major Advisor	Shri Rakesh Banwasi, Scientist Soil Science and Agricultural Chemistry CoA, IGKV, Raipur (C.G.)
e) Degree to be Awarded	Master of Science Agriculture (Soil Science and Agricultural Chemistry)

Signature of the Student

Signature of Major Advisor

Date: _____________ Signature of Head of the Department

ABSTRACT

An experiment was conducted at instructional farm of I.G.K.V., Raipur (C.G.) during *kharif* season of 2018 to study "Calibration of soil test, fertilizer dose and crop yield with and without FYM for hybrid rice under SRI in *Vertisol* of Chhattisgarh

plain".) with the objectives- 1. Evaluating response of the hybrid rice to added fertilizers (NPK) and FYM. 2. Estimation of requirement of NPK by hybrid rice 3. Evaluation of efficiencies (soil test, fertilizer and FYM efficiencies) for hybrid rice in *Vertisol*, and 4. Derivation of "soil test based fertilizer prescription equation" for hybrid rice. A special field method – "Inductive cum targeted yield model"- for soil test crop response study evolved by Ramamoorthy *et al.* (1967) was utilized in this experiment. "Re-enforced resolvable block design" was used for experiment.

First of all, three equal sized vertical fertility strips (Replication) of low fertility (L_0), medium fertility (L_1) and high fertility (L_2) level were created in the experimental field. All the strips were further divided into three equal parts (blocks) for 3 doses of FYM "0, 5 and 10 t ha^{-1}", hence total 9 blocks had been there in the experimental field. Each block was further divided into 08 equal plots. Total 24 treatment combinations comprise of four different doses of N with "0, 60, 120 and 180 kg ha^{-1}", P_2O_5 with "0, 40, 80 and 120 kg ha^{-1}" and K_2O with "0, 40, 80 and 120 kg ha^{-1}" were selected and given as fertilizer treatments. These 24 treatment combinations were again divided in to three groups of eight treatments (A, B and C) and applied in each strip.

The hybrid rice (var. IRH-103) was taken as test crop. Soil samples taken before sowing were tested and uptakes of nutrients were estimated for the calculation of basic parameters. The hybrid rice yield in L_0 fertility strip varied from 32 to 91.55 q ha^{-1} with an mean value of 68.31. Yield of rice in L_1 strip was between 37 to 94 q ha^{-1} with average of 72.27 q ha^{-1}, whereas the yield in L_2 strip was between 41.20 to 93 q ha^{-1} with average of 75.18 q ha^{-1}. For production of one quintal of hybrid rice the nutrient requirements were calculated as 1.57 kg, 0.32 kg and 1.71 kg of "N, P and K" respectively. The contribution from "N, P and K fertilizers" (as percent efficiencies) were determined as 39.87, 30.53 and 94.53 percent respectively. In same way the contribution from soil were recorded as 32.66, 73.38 and 16.39 percent for "N, P and K" respectively. The contribution from FYM was calculated as 13.01, 5.43 and 10.10 percent for "N, P and K" respectively. For SRI hybrid rice (IRH-103), equations for fertilizers adjustment were generated based on all above basic parameters for achieving a definite targeted yield. Based on the results of the study and developed fertilizer prescription equations a ready reckoners chart were also prepared for the farmers point of view.

Based on all above basic parameters following fertilizer prescription equations were derived for hybrid rice (var. IRH-103) in *vertisol* of Chhattisgarh plain.

S.No	**Fertilizer prescription equations**
1.	FN=3.93Y-0.82SN-0.33FYM
2.	FP_2O_5=1.03Y-1.03SP-0.18FYM
3.	FK_2O=1.81Y-0.17SK-0.11FYM

Here

"FN, FP and FK" represents the fertilizer N, P_2O_5 and K_2O (kg ha^{-1}).

"Y" represents crop yield. (q ha^{-1})

"SN, SP and SK" represents the NPK values of soil test. (kg ha^{-1})

FYM represents "Farm Yard Manure "(t ha^{-1}).

The fertilizer adjustment equations derived and ready reckoners chart prepared are useful for the extension workers at field level and also soil testing laboratories can utilize it for the recommendation of fertilizers on the basis of "soil test results" and amount of FYM need to be incorporated in the field.

शोध सारांश

”ोध शीर्षक	छत्तीसगढ़ के मैदानी भाग की कन्हार भूमि हेतु एस.आर.आई विधि में संकर धान के लिए गोबर की खाद के साथ एवं बिना खाद के मृदा परीक्षण, उर्वरक मात्रा एवं फसल की उपज का अंशाकन'
विद्यार्थी का पूरा नाम	अनुराग गुप्ता
मुख्य विषय	मृदा विज्ञान एवं कृषि रसायन
मुख्य पराम”ीदाता का नाम एवं पता	श्री राके”ा बनवासी, वैज्ञानिक, मृदा विज्ञान एवं कृषि रसायन विभाग, कृषि महाविद्यालय, इं. गा. कृ. वि., रायपुर (छ.ग.)
उपाधि	स्नातकोत्तर (कृषि), मृदाविज्ञान एवं कृषि रसायन

मुख्य पराम”ीदाता के हस्ताक्षर विद्यार्थी का हस्ताक्षर

दिनांक विभागाध्यक्ष के हस्ताक्षर

शोध सारांश

छत्तीसगढ़ के मैदानी भाग की ंकन्हार भूमि में एस.आर.आई विधि में संकर धान (किस्म–आई.आर.एच. 103) फसल हेतु संतुलित उर्वरक का निर्धारण करने के लिए इं.गां.कृ.वि., रायपुर के अनुदेशक प्रक्षेत्र पर वर्ष 2018 के खरीफ मौसम में प्रयोग किया गया। प्रयोग के निम्नलिखित उद्देश्य थे : 1. धान की उपज पर उर्वरक की मात्रा और मृदा परीक्षण स्तर के प्रभाव का अध्ययन करना 2. कन्हार भूमि में संकर धान के लिए पोषक तत्वों की आवश्यकता का अनुमान लगाना 3. संकर धान की फसल के लिए मिट्टी परीक्षण उर्वरक और गोबर खाद की दक्षता का अनुमान लगाना 4. संकर धान के लिए मृदा पोषक तत्वों के स्तर पर संतुलित उर्वरक निर्धारण समीकरण विकसित करना। प्रयोग प्रक्षेत्र को एक वर्ष पूर्व तैयार किये गये उर्वरता स्तरों के आधार पर तीन एक बराबर लम्बी पट्टीयों में बाटा गया तथा इन्हें L_0, L_1, L_2 नाम दिये गये। प्रयोग की रूप रेखा रि–इनफोर्सड रिजाल्वेबल ब्लॉक (Re-inforced Resolvable Block Design) में गोबर की खाद की तीन पट्टीयों (0, 5 एवं 10 टन प्रति हेक्टेयर) के साथ किया गया। प्रयोग में उर्वरक नत्रजन की चार (0, 60, 120 एवं 180 कि.ग्रा./हेक्टेयर) तथा फास्फोरस एवं पोटाश के चार–चार स्तरों (0, 40, 80, 120 कि.ग्रा./हेक्टेयर) के कुल 24 संयोजनों (21+तीन कंट्रोल) का उपचार हेतु चयन कर प्रत्येक उर्वरता स्तर पट्टीयों में अध्यारोपित किये गये।

प्रयोग में संकर धान की आई.आर.एच.–103 किस्मका एस.आर.आई विधि में औसत उत्पादन L_0 पट्टी में 68.31, L_1 पट्टी में 72.27 तथा L_2 पट्टी में 75.18 क्विंटल प्रति हेक्टेयर प्राप्त हुई।प्रयोग के परिणामों में संकर धान की एक क्विंटल उपज (दाना) प्राप्त करने हेतु1.57 कि.ग्रा. नत्रजन, 0.32 कि.ग्रा. फास्फोरस तथा 1.71 कि.ग्रा.पोटाश तत्वो की आव”यकता पाई गई।प्रयोग में मृदा परीक्षण दक्षता 32.66, 73.38, 16.39 प्रति”ात क्रम”ाः नत्रजन, स्फूर एवं पोटाश हेतु प्राप्त हुई।प्रयोग में उर्वरक दक्षता नत्रजन, फास्फोरस एवं पोटाश हेतु क्रमशः 39.87, 30.53 एवं 94.53 प्रतिशत पायी गई। प्रयोग में

कार्बनिक स्त्रोत की दक्षता नत्रजन के लिए 13.01 प्रतिशत, फास्फोरस के लिए 5.43 प्रतिशत तथा पोटाश के लिए 10.10 प्रतिशत प्राप्त हुई।

उपरोक्त मूलभूत मापदंडो के आधार पर छत्तीसगढ़ के मैदानी भाग की कन्हार मृदा में एस.आर. आई विधि में संकर धान (किस्म आई.आर.एच.–103) की फसल के लिए निम्नलिखित लक्षित उपज उर्वरक समायोजन समीकरण विकसित किया गया :

तालिका 1. उर्वरक समायोजन समीकरण

क्र.	उर्वरक समायोजन समीकरण
1	FN = 3.93 Y –0.82 SN –0.33 FYM
2	FP = 1.03 Y – 1.03 SP– 0.18 FYM
3	FK= 1.81 Y – 0.17 SK– 0.11 FYM

जहां FN, FP एवं FK कि.ग्रा. प्रति हेक्टेयर में क्रमशः नत्रजन(N),फास्फोरस (P_2O_5) एवं पोटाश (K_2O)उर्वरकों की मात्रा है। FYM टन प्रति हेक्टेयर में गोबर खाद की मात्रा है। SN, SP एवं SK कि.ग्रा. प्रति हेक्टेयर में मृदा परीक्षण परिणाम है।Yक्विंटल प्रति हेक्टेयरमें फसल की उपज मात्रा है।

कृषि विस्तार अधिकारियों एवं मृदा परीक्षक प्रयोगशालाओं की सुविधा के लिए मृदा परीक्षण के आधार पर संकर धान की लक्षित उपज प्राप्त करने के लिए नत्रजन, फास्फोरस एवं पोटाश उर्वरकों की मात्रा के गणना हेतु एक त्वरित तालिका (Ready Reckoner Chart) भी तैयार किया गया।

CHAPTER I

INTRODUCTION

Adequate and balanced supply is a pre requisite to optimum plant growth and realizing potential crop yield. The growth and the yield of crop depend upon the ability of soil fertility. Soil analysis, plant analysis and their interpretation using the critical level approach are some methods for assessing crop nutrient requirements which is the base for the fertilizer recommendations.

Plant nutrients are neither adequately available from soil reserves nor can they be procured in sufficient amount from alternative sources like organic manures, crop residues or bio-fertilizers. “Application of fertilizer nutrients by the farmer without information on soil fertility status and nutrient requirement by crop affect soil and crop adversely” (Ray and krishnaiah, 2000). “Use of right amount of fertilizer is fundamental for farm profitability and environmental protection” (Kimetu and Rouse, 2004). In the era of precision agriculture, the concept of “Soil test based fertilizer recommendation” harmonizes the much debated approaches namely; “Fertilizing the soil” versus “Fertilizing the crop” ensures the real balance between the applied fertilizer nutrients among themselves and with the soil available nutrients. Among the various methods for formulation of fertilizer recommendations, the method based on yield targeting is unique in the sense that this method not only indicates soil test based fertilizer dose but also the level of yield in realizing the yield potential of high yielding varieties of cereals and vegetable crops. ”The most appropriate balanced and economic doses of fertilizer can be evolved on the basis of soil test and crop response studies”. (Berger, 1954)

Considering the high cost of fertilizers and adverse effect of its over use on environmental and soil health, proper organic manure- fertilizer recommendations on the bases of soil test values, residual effect and yield targets becomes vital. At such point of time, unique “inductive cum targeted yield model” of Ramamoorthy *et al.*

(1967) to develop proper manure- fertilizer prescription became very useful (Santhi *et al.*, 2010). Theory for formulation of optimum fertilizer recommendation for any targeted yield was first given by Troug (1960) which was further modified by Ramamoorthy *et al.* (1967) as "Inductive cum targeted yield model". "Soil test crop response (STCR) studies help to generate fertilizer adjustment equations and calibration charts for recommending fertilizers on the basis of soil tests and achieving targeted yield of crops" (Singh and Biswas, 2000).

Rice is the major food grain crop of Indian economy. India is the world's 2nd largest producer with approximately 43.2 m. ha planted area. In the year 2016-17 the production of rice in the country was 110.15 M.T. with an average productivity of 25.5 q/ha (Pocket book of Agricultural statistics, 2017). In Chhattisgarh, rice crop occupies 4.05 million ha area and produce 8.79 million tons yield (2016-17). The productivity of rice in the state was 2.17 t/ha (Agricultural statistics, 2017) which is quite low in comparison of the national average. Area under hybrid rice is continuously increasing. Area under hybrid rice was 10,000 hectare in 1995 which drastically changed to one million hectare in 2006. Area under hybrid rice was over 2.5 million hectares during 2014, which was about 5.6% of the total rice cultivated area in the country (Vadlamani, 2016). More than 80% of the total hybrid rice area is in Eastern Indian states like Uttar Pradesh, Jharkhand, Bihar, Chhattisgarh. (Viraktamath, 2012). Due to increasing area under hybrid rice and its high yield potential than other rice varieties, there is a strong need to study the calibration of soil test, fertilizer dose and crop yield for the balanced use of the fertilizer and yield maximization of hybrid rice.

System of Rice Intensification (SRI) method of rice production was developed in Madagascar in early eighties. This method showed that the yield of the rice crop can be significantly increased by growing the rice plants in a reduced plant density generally in 25x25 cm. This method includes cultivation of rice with higher amount of organic matter. The younger seedlings are planted singly with wider spacing in a square pattern and with the amount of irrigation which keeps the soil moist but not inundated and frequent weeding which keeps the soil aerated. The seed rate in SRI method is 10-12 kg per hactare as compared to 100 kg per hectare in conventional method. The SRI method benefits plant by promoting higher root growth and higher amount of biological activity in the soil. The SRI method provides maximum and strong tillering.

Farm yard manure is an excellent source for enhancing soil health and for providing nutrients up to some extent. FYM refers to the decomposed mixture of the cattle's dung, urine, waste straw and other dairy wastages .The farm yard manures are bulky source of nutrients which generally contains 0.5% nitrogen, 0.2% phosphorus and 0.5% of potassium in it. The higher amount of FYM can lead to higher amount of organic matter and better phsico-chemical properties for soil for crop production. FYM also works as a slow release source of nutrients since it provides nutrients when it decomposes completely.

Therefore, study of the soil test based fertilizer application and response of crop for achieving targeted yield of hybrid rice in SRI method to be of great importance. In view of the above facts the present experiment entitled "**Calibration of soil test, fertilizer dose and crop yield with and without FYM for hybrid rice under SRI in *Vertisol* of Chhattisgarh plain**" will be carried out with the following objectives:

OBJECTIVES:

1. To study the crop response to added fertilizer NPK and FYM
2. To estimate the NPK requirement for hybrid rice
3. To evaluate the soil test, fertilizer and FYM efficiencies for hybrid rice in *Vertisol*
4. To derive soil test based fertilizer prescription equation for hybrid rice

CHAPTER – II

REVIEW OF LITERATURE

The literature was relevant to the present investigation entitled "Calibration of the soil test, fertilizer dose and crop yield with and without FYM for hybrid rice under SRI in *Vertisol* of Chhattisgarh plains" have been reviewed under following head:-

2.1 Regression model

2.2 Establishment of rice by SRI method

2.3 Crop response to added fertilizer and FYM

2.4 Uptake and nutrient requirement of crop

2.5 Nutrient use efficiency

2.6 Soil fertility status

2.7 Targeted yield approach

Fertilizer is any material that is either of natural or synthetic origin (other than amendments) that is applied to soil or plant for providing nutrients. Fertilizers hold the key to enhance the growth of plants. Some fertilizers also enhance the effectiveness of the soil by enhancing water retention and aeration. Considering the higher costs of fertilizer and the low purchasing power of farmers the balanced use of fertilizer becomes essential. Integration of inorganic fertilizers with the organic one also helps farmers for achieving the balanced fertilizer doses. The integrated use of nutrients not only provides the right amount of nutrients but also improves various soil properties. The most suitable, balanced and economic doses of fertilizer can be produced on the basis of soil test and crop response studies. In the soil testing we analyzed soil for various aspects which affects the crop production. Tisdale and peck

(1967) also expresses the importance of soil testing as "soil testing is as impotent to the art of crop production what the thermometer is to the medical profession"

Kanwar (1971) stated that "Soil testing as the key weapon in the armory of soil Scientists".

2.1 Regression model

Polynomial models of various degrees allow direct calculation of optimum application rate under certain conditions also the interaction of fertilizer nutrient and soil can be included hence it is quite useful to relate crop yield and fertilizer nutrients.

Colwell (1967) has demonstrated superior fitness of information of fertilizer experiments to a quadratic or similar kind of response function. A general system has been depicted by Colwell and Tisdale (1968) for the estimation of fertilizer utilizing polynomial response function and emphasized on necessity that all factors which influence yield response to the fertilizer should be included to the calibration equation. They marked a statistical procedure for changing over soil test estimation of any site into a fertilizer recommendation.

Ramamoorthy *et al.* (1974); Velayutham and Perumal (1976), Velayutham (1979) and Velayutham *et al.* (1985) have proposed a method for establishment of relationship between soil test values, added fertilizer dose and crop yields by using "multip\le regression equations" using the quadratic model as given below.

$Y = A \pm b_1SN \pm b_2SN_2 \pm b_3SP \pm b_4SP^2 \pm b_5SK \pm b_6SK^2 \pm b_7FN \pm b8FN^2 \pm B_9FP \pm b_{10}FP^2 \pm b_{11}FK \pm b_{12}FK^2 \pm b_{13}SNFN \pm b_{14}\ SPFP \pm b_{15}\ SKFK.$

Where, Y represents crop yield, A represents intercept, b1 to b15 are regression coefficient and S and F represents available soil and fertilizer nutrients, respectively.

Crop response from added nutrients is expressed by various mathematical models. To relate soil nutrient levels to crop growth, mathematical expressions such as quadratic, exponential and straight lines are used. Immobile nutrients for example, P, K, Ca and Mg that are consumed by soil hence consequently diffuse, migrate and move at such moderate rate that the root tip penetrate the soil. Such supplement can usually be related with development through either the quadratic or exponential equation. Mobile nutrients, for example, nitrates and borates are most certainly not adsorbed by the soil and can diffuse, relocate and move in and out of soil with water at quicker rates are more often related to plant development through straight line function (Melsted and Peck, 1977).

Sharma and Singh (2005) conducted field experiment at *Haplustept* of Delhi on two varieties of wheat. The experimental results were statistically analyzed for multiple regressions. They have taken wheat grain yield as dependent variable and soil available nutrient (N, P and K) fertilizer nutrients and interactions between fertilizer nutrients and soil as independent variables. Highly significant R^2values of 0.88 and 0.91 for multiple regression equations were obtained.

Srivastava *et al*. (2017) carried out the calibration of multiple regression equation, the relationship of rice yields with different nutrients working as independent variables were derived by using regression analysis for rice in the *Kharif* season of 2008 and 2009 for evaluating the contribution of soil tests for modifying the crop response to added fertilizer nutrients. Results indicate that the larger part of variation for hybrid rice grain yield was accounted by N alone. However, its quadratic term gave better fit into the data as evidence from the higher R^2 value (0.80) with curvilinear equation in both the seasons. High response of hybrid rice was found because of the high N requirement and being a mobile nature of this element, it is available to the plant in the root system sorption zone.

2.2 Establishment of rice under SRI method

Many countries have been practicing the System of Rice Intensification (SRI) technique. In India, it is also becoming popular among farmers. The SRI method was developed by Henri De Laulanie (1983) after working for over two decades on the rice crop. By his observation and experimentation, he showed that rice crop gives better agronomic and economic results with moist soil which is not continuously saturated. The SRI method needs a high application of organic matter in the field. SRI methodology deals with the rice production in irrigated condition, according to local conditions that change the nutrients, soil and water management practices. In the SRI method, 10-12 days old rice seedlings are transplanted used and only one seedling transplanted per hill was in a square pattern with a recommended spacing of 25 x 25 cm. The SRI method saves water by 20-25 %, saves labor wages up to 14%, and increases crop productivity by 20-45% and seedling savings by 70-80 %. In the SRI method takes up to 10 days less duration for maturity as compared to other methods. The grain weight is higher in the SRI method with less chaffy grains (Kumar *et al*. 2015)

SRI is a well-planned rice planting method that generally needs a lesser amount of land, labor and water resources and also protects soil and groundwater from chemicals. Lin *et al*., (2006) concluded that the use of SRI method in rice can lead to superior phenotype and agronomic practices for a wide range of rice genotypes.

Krishna *et al*. (2008) evaluated the influence of SRI method on yield and quality of rice (variety- BPT-5204) in Agricultural Research Station, Sirsi, Karnataka during *kharif* 2004-05.The treatment combinations with SRI method showed more number of productive tillers. SRI method produced significantly higher (3.99 t ha^{-1}) yield over traditional method (3.45 t ha^{-1}). The percent increase in yield per hectare under SRI method was 15.65 over traditional method.

Malwath (2008) field trial was conducted in *kharif* 2005 and 2006 to compare the System of Rice Intensification (SRI) method over to Conventional method of planting of rice. The results revealed that highest grain yield 6735 and 6125 kg ha^{-1} was recorded with green manuring and FYM under SRI method of planting, respectively as compared to conventional method (6467 and 6053 kg ha^{-1} yield) during both the years.

Verma *et al*. (2014) concluded that SRI method with some manipulations (10 days aged seedlings + 100% nutrients through inorganic or 50% through organic +

50% through inorganic + irrigation as per SRI) contributed 13.52% higher grain yield (7.52 t ha^{-1}) and 16.80% higher net income over recommended practices of hybrid rice.

Kumar (2015) carried out a trial at Agricultural Research Station, Thirupathisaram, Tamil Nadu during *kharif* and *rabi* of 2011-12 to examine the different methods of cultivation on growth and yield of rice. The treatment structure includes wet seeding, drum seeding, arbitrary transplanting, line planting, SRI square planting and SRI machine planting. Among the diverse development techniques, SRI altogether impacted the development and yield characters and yield was comparable to SRI square planting. The greatest plant tallness, number of tillers per hill, LAI, dry matter production, number of panicles m^{-2}, and number of grains $panicle^{-1}$, panicle length, grain yield, straw yield, net return and return per rupee were recorded under SRI machine planting .

Bhavya and Kumar (2016) conducted a field experiment in *kharif* season of 2015 on sandy loam soil of Bihar to compare the performance of SRI method of plantation and by other conventional method of rice establishment under the STCR approaches. The STCR approach recorded the grain yield 8314 kg ha^{-1} whereas method of establishment by SRI with STCR approach achieved higher grain yield of 8348 kg ha^{-1}.

Hidayati and Anas (2016) worked on rice crop in Indonesia for the effect of the SRI method on the rooting pattern of the rice crop and reported that the plant roots were significantly longer and heavier under the System of rice intensifications compared to the conventional method which increased the water and nutrient uptake and indirectly increased the yield of crop.SRI method also showed characteristics such as a higher number of root hairs (60% more) healthier root and more vigorous roots.

Shukla *et al*. (2016) revealed that in one bunch of paddy panicles(var.Kranti) in the SRI method of paddy there were 3500-3700 grains while in the traditional technique just 2400-2600 grains were gained.

Nahar *et al*. (2018) conducted an experiment and found that the highest grain yield of 4.49 t ha^{-1} was recorded with the SRI method along with BRRI recommended fertilizer doses.

Chandankutte *et al*. (2018) carried out an experiment in Agriculture Research Farm (B.H.U.) to evaluate various rice establishment methods and INM practices on nutrient parameters and quality attributes of rice. The results of the experiment showed that the maximum nutrient uptake (97.56 kg ha^{-1} N, 15.58 kg ha^{-1} P and 113.24 kg ha^{-1} K), Highest yield and better quality parameters viz. protein content in grain (9.04 %) was found under SRI method of transplanting as compared to another method of transplanting .

Mittal *et al*. (2018) conducted a field experiment and revealed that in SRI method soil test-crop response based fertilizer application treatment performed excellently as compared to all other approaches of fertilizer application in terms of net returns and benefit-cost ratio. However, the STCR approach was satisfactory up to yield target of 4.0 mt ha $^{-1}$

Kangile *et al*. (2018) carried out a field experiment to validate the SRI method for small farm holders in Tanzania. Farmers used the SRI method for rice cultivation and resulted that the highest yield of 9.1 t/ha was found by TXD 88 variety whereas the lowest yield was received by SUPA variety (6.2 t/ha). It indicates that the SRI method leads to higher yield. Also, all the other varieties grown under SRI method performed well.

Choudhary and Suri (2018) worked on short duration rice hybrids sown under the SRI method. He worked in rice crop from 2007-12 and also conducted 10 multi-location trials .the results showed the higher productivity, as well as higher resources, use efficiency was received by rice hybrids as compared to high yielding verities both under conventional and SRI transplantation method. The rice hybrid Arize-6129 showed wider adaptability for conventional transplanting and SRI under varying bio-physical regimes. Arize-6129 rice-hybrid under SRI yielded 6.75–6.88, 7.00–7.86, and 7.58-8.32 t ha^{-1} grains in rainfed medium-fertility, irrigated medium-fertility and irrigated high-fertility situations respectively. The net income return was 29.4% higher in the SRI method as compared to the conventional transplanting method.

Potkile *et al*. (2018) conducted an experiment in the College of Agriculture, Nagpur for the effect of various planting methods on rice crop. The results revealed that the rice crop under the SRI method had higher grain yield (27.96 q ha^{-1}) and higher straw yield (42.93 q ha^{-1}) as compared to other planting methods. Highest B:C ratio of 4.01 was also recorded with the planting method SRI transplanting at 25 cm x 25 cm which was followed by SRI transplanting at 20 cm x 20 cm.

2.3 Crop response to added fertilizer and FYM

The addition of fertilizer and FYM holds the key for the higher yield. The response of the crop to added fertilizer and FYM is affected by various factors such as inherent soil nutrient status, the type of soil as well as crop verities. The existing level of some of the nutrients such as Nitrogen, phosphorus and zinc levels are low in Indian soil. The level of one nutrient significantly affects the level of other nutrients also. The inorganic and organic sources of nutrients together are beneficial in most of the conditions.

Gill *et al*. (2012) studied the influence of “integrated nutrient management” (INM) in basmati rice and found that the highest grain yield (34.9 q ha^{-1}) was obtained with combined application of FYM (15tons) with 50 % of recommended nitrogen dose (100kg).

Singh *et al.* (2013) evaluated the effect of N, P, K levels ,FYM on growth and yield of rice crop (HUBR 2-1) and concluded that integration of moderate NPK levels 100 % of RDF (120:60:60 Kg NPK) with FYM (5 ton ha^{-1}) has given good net return (Rs.30,289 ha^{-1}) as well as benefit-cost ratio(1.27).

Reddy *et al*. (2017) studied the effect of applied FYM on the yield of the rice crop and on the cracking pattern of the soil and found that the yield of the rice crop significantly increased with higher FYM doses. The grain yield (4.86 t ha^{-1}) and straw yield (6.41 t ha^{-1}) was recorded high when 10 tons FYM was applied. Also, no. of cracks was less in the treatment with 10 tons of FYM dose as compared to no FYM.

Verma and Kaur (2016) conducted a field experiment to evaluate the effect of nitrogen level alone with farmyard manure, phosphorus (p) and potassium (k) on grain yield of rice and wheat crop. The results showed that the treatment receiving nitrogen along with the FYM produce a maximum grain yield 73.4 q/ha in rice and 72.1 q/ha in wheat.

Dash *et al.* (2017) evaluated various combinations of inorganic and organic sources of nitrogen on rice crop planted under SRI method. The results indicated that among the different treatments, the combined application of organic and inorganic sources of nitrogen showed a significant influence on the growth and yield of hybrid rice grown under SRI. Application of 100% RDF (100:50:50 kg NPK) recorded the highest plant height but the maximum number of tillers m-^{2}, leaf area index (LAI) and dry matter accumulation (DMA) were observed under 75% RDFN + 25% N through vermicompost and were comparable with 75% RDFN + 25% N through FYM.

Mitran and Mani (2017) studied the effect of various combinations of organic and inorganic sources of nutrients on rice crop and resulted in the application of nitrogen, phosphorus, potassium and its combination with FYM, PS, and green manuring increased the grain yield of rice. All plots treated with organic amendments showed better uptake as well as the use efficiency of applied phosphorus. The positive yield trend of rice was maintained due to buildup of P from various organic inputs.

Anning *et al.* (2018) studied the effect of various nitrogen sources combined with different soil management practices and results revealed that an integrated dose of urea and compost fertilizer with alternate wetting and drying of the field produced higher grain yield (5.3 t ha^{-1}) and N use efficiency (40%).

2.4 Uptake and nutrient requirement by crop

Nutrients are essential for plants to complete their life cycle and scarcity of any essential nutrient inhibits the plant growth stimulates slow growth or cell death. Plant needs some of the nutrients (macronutrients) is larger quantity while some of the nutrients are required in smaller quantity (micronutrients).

Krishnakumar *et al*. (2005) worked for the optimization of NPK requirements for hybrid rice and found that the application of NPK in the ratio of 150:75:50 kg ha^{-1} resulted highest grain yield for hybrid rice whereas the fertilizer treatment of 150:50:50 kg ha^{-1} NPK registered the higher total phosphorus and potassium uptake. NPK doses of 200:75:75, 200:10:100, 200:50:75 kg ha^{-1} gave higher soil available NPK after harvesting of hybrid rice in soils.

Srinivasan and Angayankanni (2008) worked on STCR rice (ADT-36) at Annamalainagar and revealed that in rice The percent contribution of K from FYM was 28.79% . the F_{K2O} requirement to get a yield target of 70 q ha^{-1} of rice was 135 kg ha^{-1} with fertilizer alone, whereas the F_{K2O} requirement reduced to 110 kg ha^{-1} with fertilizer + FYM .

Mete (2010) conducted field experiment in rice - yellow sarson cropping system to estimate the fertilizer requirement for specific yield targets in old alluvial zone of West Bengal and reported nutrient requirement of 20.14 kg N, 17.32 kg P_2O_5 and 11.90 kg K_2O for one tonne production of rice.

Prasad *et al*. (2011) evaluated that the most extreme uptake of NPK was seen at the point when half N was substituted by FYM in maize (114.6, 23.9 and 125.5 kg ha^{-1}), wheat (99.7, 18.1 and 89.8 kg ha-1) and maize-wheat framework (214.3, 42.0 and 215.3 kg ha^{-1}), individually which was seen to perform similar with 50% N through FYM+50% through RDF and 100% NPK in both the crops and furthermore discovered that the NPK take-up by maize, wheat and in complete cropping system increased with increase in dose of fertilizer. Substitution of half N by FYM displayed better reaction in supplement take-up over chemical fertilizer because of the constant supply of supplements all through the developing period of crops. (Laxminarayana, 2006).

Regar and Singh *(*2014) worked on the rice crop (var.Saryau-52) under soil test-crop response correlation in Varanasi and reported that the nutrient requirement of N, P_2O5, and K_2O for the production of one quintal of rice yield was found to be 2.56 kg, 0.56 kg, 2.21 kg respectively.

Ahmed *et al*. (2015) worked on autumn rice (var. Pusa 2-21) under soil test-crop response in 2011-12 under integrated plant nutrition system and reported that The nutrient requirement (NR) for producing one quintal of autumn rice was found to be 2.40 kg, 0.84 kg and 2.25 kg of N, P_2O_5 and K_2O, respectively.

Sahu *et al*. (2017) worked on "soil test-crop response" rice-wheat cropping system on *vertisol* at IGKV Raipur under integrated plant nutrient system. Based on the experiment she reported that the nutrient requirement for producing one quintal of rice grain (var. Swarna) was 1.54 kg of N, 0.29 kg of P_2O_5 and 1.72 kg of K_2O and that for wheat was 1.94 kg N, 0.53 kg P_2O_5 and 1.94 kg K_2O.

Srivastava *et al*. (2017) conducted a field experiment on rice crop (var. Indira Sona) in *vertisol* of Chhattisgarh plains and resulted that rice crop required 1.52 kg N, 0.38 kg P_2O_5 and 2.03 kg K_2O to produce one quintal of grain yield.

` Verma *et al*. (2017) found that the average nutrient requirement for the production of one quintal of mustard was 5.22 kg N, 0.99 kg P_2O_5 and 4.25 kg K_2O.

Mittal *et al.* (2018) conducted an experiment on rice (var.HPR-2612) in palampur (H.P.) in *Alfisols* and observed that the "soil test crop response (STCR) approach based fertilizer application" significantly increased the available nitrogen (N), phosphorus (P) and potassium (K) status in the soil as compared to all the other approaches of fertilizer recommendations. In SRI method at 50% flowering stage the available NPK content was highest in STCR based yield target of 5 t ha^{-1} (370 kg ha^{-1} N, 38.3 kg ha^{-1} P, 147 kg ha^{-1} K).

Kumar *et al.* (2018) reported that the grain yield in rice was higher with STCR equation based fertilizer application as compared to Farmers' practice (Imbalanced fertilization 250:155:133 kg ha^{-1}) and Recommended package of practices (100:50:50 kg ha^{-1}).

Beena *et al.* (2018) studied the STCR based targeted yield model on chilly in *Vertisol* of kerela and evaluated that 11.85, 0.60 and 14.03 kg of N, P_2O_5 and K_2O respectively were required for producing one-tonne fruit yield of chili.

Kashyap *et al.* (2018) worked on soil test-crop response in hybrid rice (c.v. US-382) and reported that for producing 1 quintal of grain yield 2.00 kg N, 0.31 kg P_2O_5 and 2.35 kg K_2O was required.

2.5 Nutrient use efficiency

Many agricultural field soils are deficient in some of the essential nutrients needed for plant growth. The soil works as a source of nutrients for plants other than that the fertilizers and amendments are given to the soil also adds to nutrient availability. The efficiency of the given source of the nutrient is also an important prospect since it has been estimated that the applied fertilizers have an efficiency of 50% or less for N, Less than 10% for P and about 40% for K.

Srinivasan and Angayankanni (2008) studied the contribution of potassium from various sources of nutrients in rice (var. ADT-36) in Annamalainagar and found that contribution from the soil, contribution from fertilizer and contribution from FYM was 10.67, 54.05 and 28.79 percent respectively for potassium.

Regar and Singh (2014) evaluated that the nutrient contribution for rice (var. Saryau-52) at B.H.U. Varanasi from the soil was 26.35, 51.17 and 26.14 of N, P and K nutrients. Contribution from fertilizer and FYM were 54.03, 36.35, 75.38 and 18.59, 3.10, 8.56 of N, P and K nutrients.

Parihar *et al.* (2015) worked on STCR based integrated plant nutrient system for targeted yield concept in maize and resulted that in all the four locations where the experiment was conducted the percent achievement of the target yield was under +/-

10% variation and proved the validity of the STCR equation for fertilizer prescription in maize.

Verma *et al*. (2017) worked on mustard crop at B.H.U. Varanasi and reported that the percent contribution of soil nitrogen, phosphorus, and potassium were 23.94, 70.45 and 22.14%. The percent contribution from applied fertilizer was 42.53, 21.44 and 90.52 percent of nitrogen, phosphorus, and potassium respectively.

Srivastava *et al*. (2017) conducted an experiment on integrated nutrient management in rice crop in *vertisols* of Chhattisgarh plains and estimated that Fertilizer and soil test efficiencies 27.75, 24.60 and 87.15 percent and 25.60, 66.35 and 15.85 percent respectively for NPK. The efficiency of FYM in terms of available nutrient was evaluated as 13.85, 7.10 and 11.05 percent respectively.

Sahu *et al*. (2017) carried out an experiment on SRI rice in *vertisol* of Chhattisgarh plains and found that the contribution of soil in percent was 33.64% N, 81.86% P, and 16.87% K for rice and soil's contribution for wheat was 9.96% N, 45.50% P, and 4.87% K.

Sahu *et al*. (2017) studied the efficiency of various sources of nutrients for calibration of "Soil Test Based Balance Fertilizer Doses" with FYM for Wheat and reported that the efficiency of fertilizers for N, P and K was estimated as 34.4, 22.0 and 72.1 percent respectively. The soil test efficiency for high-density wheat crop was observed as 13.08% N, 65.02% P, and 7.98% for K. The farmyard manures efficiency was found to be 13.7% N, 5.6% P and 8% for K. The contributions of fertilizer towards crop response were 39.55% N, 28.22 % P and 97.87 % K for rice and 29.49% N, 20.44 % P, 61.57% K for wheat. The farmyard manures contribution was 23.30 % N, 7.69 % P and 10.73 % K for rice and 10.26% N, 5.50 % P, 4.39% K for wheat.

Raghuveer *et al.* (2017) studied the effect of fertilizers applications and soil test values on yield and nutrient status of garlic crop and revealed that the nutrient usage effectiveness of N, P and K from soil source was discovered 12, 66 and 26 percent separately while the percent usage of essential fertilizers given through fertilizers was found 41, 36 and 51 percent for N, P and K, individually.

Beena *et al.* (2018) studied the contribution of various sources of nutrients and resulted that the percent contribution of P_2O_5 (11.19 kg ha^{-1}) from soil was relatively higher while the percent contribution of N was higher from fertilizer source (152 kg ha-1) and FYM (15.59 kg ha^{-1}).

2.6 Soil fertility status

The expansion inaccessible potassium content in the treatment STCR approach may be because of the higher amount of potassium applied. Comparable outcomes were accounted for by Jagadeeswari and Kumaraswamy (2000).

Verma *et al*. (2002) found that “prescription based fertilizer recommendations for the yield targets” could be incorporated with extra 5 t FYM ha^{-1}, would not just increment rice, maize and wheat yields by 4.2 to 5.7 q ha^{-1} yet additionally develop soil richness regarding accessible N, P_2O_5 and K_2O and DTPA extractable micronutrients.

Subehia *et al*. (2005) detailed that the expansion of FYM or lime alongside organic fertilizers, not only continued higher harvest yields, yet additionally improved the soil quality too. Imbalanced utilization of inorganic fertilizers then again decreased the crop profitability and disintegrated the soil wellbeing as far as expanded soil acidity and high P adsorption. The ceaseless utilization of chemical fertilizers diminished the soil pH altogether in every one of the treatments with the exception of in the lime-treated plots. Nitrogen alone (urea) had the most malicious impact on soil pH. The organic carbon substance of the test plots expanded, because of continuous farming. Among the accessible N, P and K, just P demonstrated a noteworthy develop over the initial level, aside from treatment wherein it was not included.

Dalal and Nandkar (2011) worked on cotton crop in dark soil to research the impact of different dimensions of NPK on the plant stature, number of branches and on the seed yield. NPK application from 20:10:10 kg $ha^{-1,}$ logically and altogether improved the seed yield. The greatest seed yield was with the utilization of 50:40:25 kg NPK ha-1, while the NPK application at the rate of 60:50:30 and 70:50:35 kg NPK ha^{-1}, gets decline in Yield of supply (NPK), resulting into a decent seed yield of Brassica juncea (var. Pusa bold).

2.7 Targeted yield approach

The soil testing program can be used to get an idea about nutrient supplying power of soils, crop response to added nutrients and amendments needs. Soil test calibration that is intended to establish a relationship between the levels of soil nutrient determined in the laboratory and crop response to fertilizers in the field permits balanced fertilization through the right kind and amount of fertilizers. The most important basic data required for formulating fertilizers recommendations for targeted yield are:-

i. The nutrient requirement in kg q^{-1} of produce, grain or other economic produce.
ii. The percent contribution from the soil available nutrients.
iii. The percent contribution from the applied fertilizer nutrients.

. Bera *et al.* (2006) carried out a “soil test-crop response correlation studies” and validity of the yield target of 7 and 8 tons per hectare was tested in farmer’s fields and the variation in yield target was less than 10 %. The percent achievement of the targets aimed at a different level was more than 90% which showed that soil test based fertilizer recommendations approach was economically viable with relative uniform cropping practices and socio-economic conditions.

Chaubey *et al.* (2015) studied the effect of STCR technology for target yield approach on rice in Bhatapara (C.G.) The demonstrated STCR technology was able to increase the yield of hybrid rice & improved rice over the framers practice 11.7 and 13.9 percent, respectively. The value of net returns from demonstrated STCR technology was observed to be Rs. 48579 & Rs. 35117 in comparison to farmers practice i.e. Rs. 42080 & Rs. 18080, respectively for hybrid rice & improved rice. The Benefit-Cost ratios of STCR technology and farmers practice were 3.67 & 3.35 and 3.38 & 2.27, respectively for hybrid rice & improved rice.

Tegegnework *et al.* (2015) worked on the response of soil test-crop response (STCR) based approach on yield and quality of rice the results revealed that the targeted yield approach had higher head diameter, 100 seed weight, no of filled seed head, seed filling percent, seed yield ha^{-1},over yield ha^{-1}, oil content, and oil yield. Also, a higher benefit-cost ratio was observed. Hence he concluded that the STCR approach had positive quantitative and qualitative traits of sunflower.

Sellamuthu *et al.*(2016) conducted a “soil test and target yield based balanced fertilizer prescription” for rainfed maize and the extent of saving of inorganic fertilizers for rainfed maize was evaluated using the fertilizer prescription equation under IPNS with application of FYM @ 12.5 t ha^{-1} was 22, 17 and 20 kg of fertilizer N, P and K respectively.

Das *et al.* (2016) conducted field trials on autumn rice- winter rice crop sequence and results revealed that treatment based on targeted yield precision model with and without “integrated plant nutrient supply”(IPNS) component ensured higher grain yield and additional net profits over farmers practice and conventional fertilizer recommendations.

Basavaraja *et al*. (2016) worked on inductive cum targeted yield model to quantify the fertilizer requirement for puddled rice crop based on soil test-crop response correlations studies and the results revealed that the grain yield received was significantly higher (65.73 q ha^{-1}) in STCR integrated approach with 75 q ha^{-1} target. The results suggest that targeted yield equation developed under puddle condition can be well adopted for both wetland and aerobic conditions of Karnataka.

Rajput *et al.* (2016) studied the effect of soil test based long term fertilization targeted yield approach on various aspects of rice crop in *vertisols* of central India and concluded that the balanced fertilization based on soil test targeted yield approach performed better over the general recommended dose of fertilizer. The STCR based recommendations significantly enhanced the soil organic carbon, available NPK and also the microbial activity.

Pacharne *et al.,* (2016) completed a field experiment at Rahuri, Maharashtra in groundnut crop under 4 nutrient management practices viz. recommended dose of fertilizer (RDF), fertilizer dose as per soil test, fertilizer dose as per soil-test crop response (STCR) equations and control (main-plots). The yield target of 2.5 t ha^{-1} was accomplished in the rainy season (*kharif*) groundnut by utilization of fertilizer according to STCR condition with under 10% variety (−5.8%). At the finish of the 2 years cropping cycles, use of fertilizers according to STCR condition (2.5 t ha^{-1}) to kharif groundnut, trailed by 75% RDF (75, 37.5, 37.5 N, P_2O_5, K_2O kg/ha) to onion during the winter (*rabi*) season found most gainful recommendation to accomplish the greatest yield and fiscal advantages in groundnut-*rabi* onion editing framework.

Madhavi *et al.* (2017) studied the STCR approach for targeted yield and an experiment was carried out to validate the STCR equation developed for Bt cotton and concluded that for target yield of 30 q ha^{-1} with chemical fertilizers the yield obtained was 30.03 with STCR approach which was higher as compared to farmers practices of 27.71 q ha^{-1} . Also, a higher benefit-cost ratio was achieved with the targeted yield approach as compared to farmers practice.

Kumar *et al*. (2018) worked on "soil test based nutrient management" of rice in Baloda bazar. The STCR equation based application of fertilizer with a target yield of 50 q/ha. Performed better than farmer's practices and recommended dose also. These results clearly indicated that the application of fertilizers to crops based on soil test values and the target yield approach was effective in getting the higher yield.

Choudhary *et al.* (2019) conducted a field experiment to evaluate the effect of STCR- based manures and fertilizer doses for the targeted yield approach on the growth and yield of rice and also in various chemical properties of soil. The results revealed that the highest yield was found with a target yield of 60 q ha^{-1} with 5 t FYM doses and also the chemical properties such as available nitrogen, phosphorus, and potassium were found higher in targeted yield approach based nutrient doses. Hence it can be said that the integrated use of NPK+FYM based on STCR approach gives higher yield and also sustains the soil fertility.

CHAPTER – III
MATERIALS AND METHODS

This chapter deals all the materials and methods used during the investigation under the following sub heads:

3.1 Experimental site

3.2 Soil Characteristics of experimental field

3.3 Experimental details

3.4 Treatment details

3.5 Technical program of work

   3.5.1 Field preparation

   3.5.2 method of transplanting

3.6 Soil analysis for nutrient status of experimental plots

3.7 Observations recorded

   3.7.1 Plant Growth parameters

   3.7.2Yield attributing parameters

3.8 Plant analysis for uptake study

3.9FYM analysis for uptake study

3.10 calculation of basic parameters

3.11 Interpretations of soil test in terms of quantity of fertilizer

3.12 Statistical analysis

3.1Experimental site

Field experiment was carried out at research farm of I.G.K.V., Raipur during *Kharif* season of 2018 for soil test crop response correlation study with application of different combination of N, P, K nutrients and FYM in order to evolve "Calibration of soil test, fertilizer dose and crop yield with and without FYM for hybrid rice under SRI in *Vertisol* of Chhattisgarh plains".

3.1.1Geographical situation

Trial site is situated at research farm of I.G.K.V., Raipur in Raipur city which is belongs eastern part of Chhattisgarh state and lies at 21^{o}16" N scope and 81^{o} 36" E longitudes with altitude of 298.56 meter over the mean ocean level.

3.2 Soil Characteristics of experimental field

The experimental field's soil belongs to the *vertisol* order of soil which is identified as Arang 2 series. Soil is represented as typical fine montmorillonitic, hyperthermic, udic chromustert. The soil is locally recognized as kanhar. The soil is clayey in texture ,dark brown to black in colour ,neutral to alkaline in reaction due to presence of lime in lower horizon. The soil structure varies from course angular blocky to massive and cloddy and in few cases from prismatic or columnar. The soil samples (0-15 cm) were gathered from the trial site before the initiation (Kharif 2018) of the investigation and its fertility richness status was evaluated. Some physico-chemical properties of the exploratory soil are given in the table no. 3.2.1.

3.2.1 Climate and Weather condition

The area comes under sub humid condition. The normal yearly precipitation of the zone is 1400-1600mm. The more noteworthy measure of precipitation happens among June and September month which is main rice developing season. The most hottest and coolest month are May and December, respectively. The detailed weekly meteorological information recorded from meteorological observatory during the yields time frame is given as below.

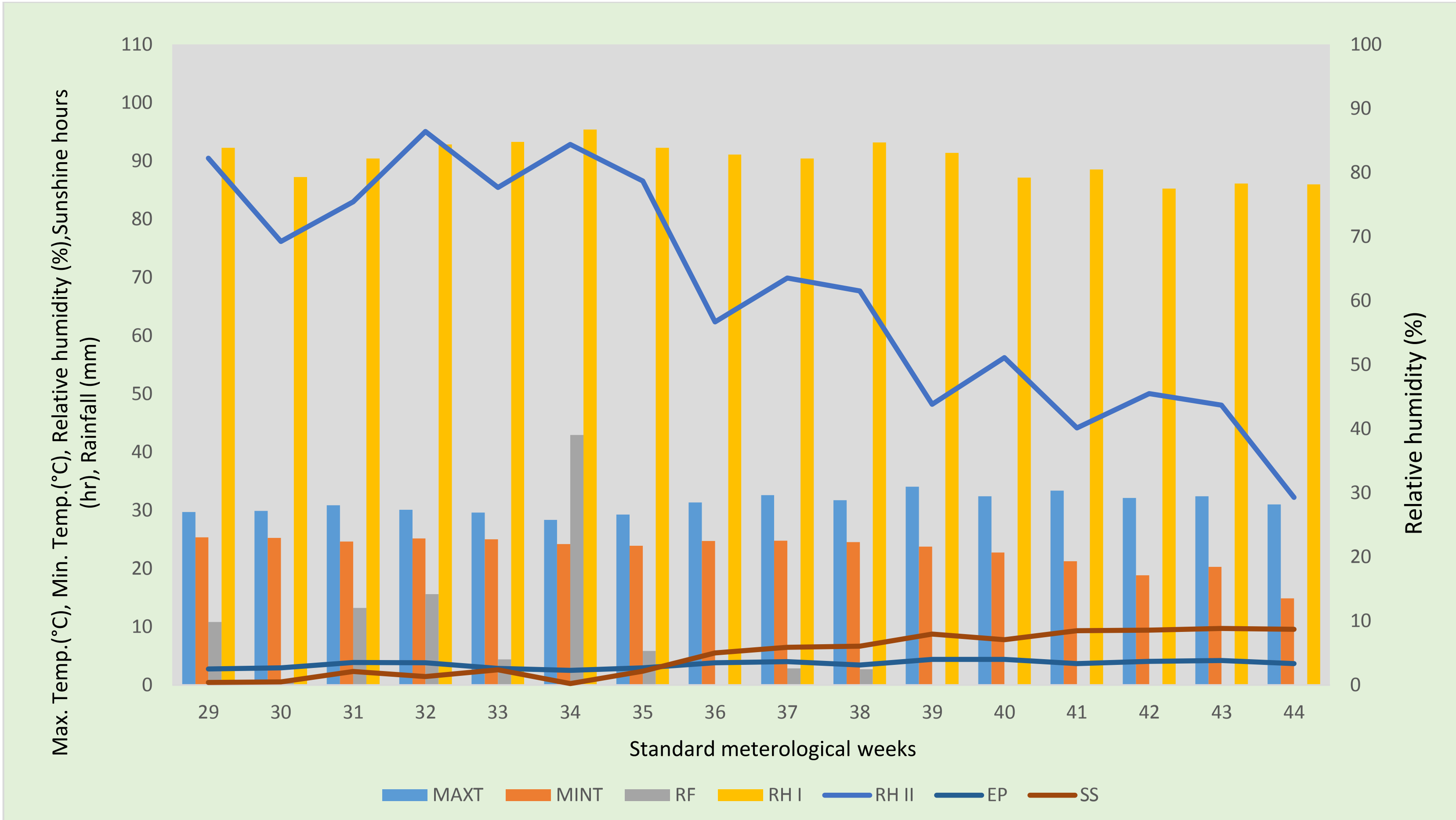

Fig.3.1 Meteorological data during the crop growth period (weekly) in *Kharif* 2018

Table 3.1.2 Initial physico-chemical properties of experimental soil

S. No.	Properties	Value
1	pH (1:2.5)	7.7
2	EC (dS m^{-1})	0.2
3	Organic C (g kg^{-1})	5.6
4	CEC [C mol (p+) kg^{-1}]	36.11
5	Alkaline KMnO4-N (kg $ha^{-1)}$	221
6	Olsen's P (kg ha-1)	19.3
7	Neutral Normal NH4OAc. Extractable -K (kg ha^{-1})	496
8	Mechanical analysis	
	Sand (%)	24
	Silt (%)	23
	Clay (%)	53
9	Textural class	Clayey

3.3: Experimental details

The field is splitted in three equal sized vertical strips and is represented as L_0 (low fertility strip), L_1 (medium fertility strip) and L_2 (high fertility strip). Before experiment the graded doses of N, P and K fertilizers are given in the field for creating an fertility gradient and for getting the needed variation in soil fertility in different strips. By applying 0-0-0, 100-75-50 and 200-150-100, kg ha^{-1} of N, P_2O5 and K_2O in L_0, L_1 and L_2 the soil fertility variation is created according to N, P and K levels in strip. Different sources of N, P and K such as urea, DAP, and muriate of potash were used. In fertility strips ranges of soil fertility were created which were evaluated in terms of variations in yields and soil test values.

After creating three equal long fertility strips, each strip (or replication) were further divided into three equal parts for three levels of FYM (0, 5 and 10 t ha^{-1}) and was regarded as block. So that there was each strip have three blocks. The three strips on each level of FYM were the three blocks and hence total 9 blocks has been there in the experimental field. Each block was further divided into 08 equal plots. There were total 72 plots in the experiment.

Total 24 treatment combinations of various of doses of N, P and K fertilizers (21 combinations + 03 control) were selected for the application in each fertility strip.

All three blocks in each strip were introduced in a *re-inforced ressolvable block design* such that the 24 selected treatment combinations were divided in to three groups (A, B and C) of eight treatments (seven combinations and one control) and applied.

Table 3.3.1: Experimental details.

Soil	*Vertisol*
Crop	Hybrid Rice
Plot Size	5m x 4m
Spacing	25 cm X 25 cm
Method of establishment	SRI
Experimental Design	Re-inforced Resolvable Block Design
Replication	3 (L_0, L_1 and L_2 as fertility strips)
Number of Blocks within replication	3 (0, 5, 10 t ha^{-1} as FYM levels).
Total number of treatment combinations per block	8 (7+1 Control)
Total no of selected treatments per replication	24 (21+3 Control) (As 3 blocks in each replication)
Level of nutrients for treatment combination	
Four doses of N-	4 (0, 60, 120, 180 kg ha^{-1})
P_2O_5 levels	4 (0, 40, 80, 120 kg ha^{-1})
K_2O levels	4 (0, 40, 80, 120 kg ha^{-1})
Variety	IRH-103
Date of Nursery raising of Rice	23/06/18
Date of transplanting	07/07/18
Date of harvesting	29/10/18

3.4: Treatment detail

Total 24 treatment combinations of four levels of each of N (0, 60, 120 and 180 kg ha^{-1}), P_2O_5 (0, 40, 80 and 120 kg ha^{-1}) and K_2O (0, 40, 80 and 120 kg ha^{-1}) was selected and given as fertilizer treatments. Theses treatment combinations were divided in to three groups (A, B and C) of eight treatments and applied in each strip.

Table 3.4.1: Selected treatment combinations of N, P_2O_5, K_2O levels (Kg ha^{-1}) for each fertility strip.

	A		B		C
T1	120:120:120	T8	180:80:80	T15	60:40:40
T2	180:120:120	T9	180:80:40	T16	60:40:80
T3	120:120:80	T10	180:120:40	T17	180:80:120
T4	120:80:120	T11	180:120:80	T18	120:80:0
T5	120:0:80	T12	120:40:80	T19	120:80:80
T6	0:80:80	T13	60:80:80	T20	120:40:40
T7	180:40:40	T14	60:80:40	T21	120:80:40
Control	0:0:0	Control	0:0:0	Control	0:0:0

3.5 Technical program of work

The research experiment for all India coordinated research project on soil test crop response was conducted according to the sanctioned layout plan. Ramamoorty *et al.*(1967) developed a special field technique which is currently being implicated in the experimental field.

The experiment was conducted with SRI rice in *Kharif* season of 2018. The experiment has three strips. Each strip constitutes 3 blocks and total 9 blocks are there and each block has 8 selected treatments. Urea, DAP and Muriate of potash were used as the fertilizer for providing N, P and K nutrient, respectively. Full dose of P_2O_5 and K_2O were applied at time of sowing and N was applied in four splits. Plot-wise soil samples (0-15 cm)were collected before application of fertilizer and FYM treatments. Lay out plan is given in the table no.3.5.1

Fig.3.2 Lay out plan for STCR Hybrid Rice (var- IRH -103) Expt. in *Vertisols* during Kharif 2018 at Raipur of C.G

L 2: 4.0 m; 0.75m; L 1: 1.50 m; L_0

Plot size: 5 m × 4 m; 1.25 m between blocks

	L 2				L 1				L_0			
FYM 0 t ha^{-1}	N 120 P 120 **72** K 120	N 180 P 120 **66** K 40	N 180 P 80 **60** K 120	N 0 P 80 **54** K 80	N 120 P 80 **48** K 0	N 60 P 80 **42** K 80	N 0 P 0 **36** K 0	N 120 P 40 **30** K 80	N 120 P 80 **24** K 40	N 60 P 40 **18** K 40	N 0 P 0 **12** K 0	N 120 P 0 **6** K 80
	N 0 P 0 **71** K 0	N 180 P 120 **65** K 120	N 180 P 120 **59** K 80	N 60 P 40 **53** K 80	N 120 P 120**47** K 80	N 120 P 80 **41** K 80	N 180 P 80 **35** K 80	N 180 P 40 **29** K 40	N 120 P 40 **23** K 40	N 60 P 80 **17** K 40	N 180 P 80 **11** K 40	N 120 P 80 **5** K 120
FYM 5 t ha^{-1}	N 120 P 80 **70** K 120	N 120 P 0 **64** K 80	N 60 P 40 **58** K 40	N 60 P 80 **52** K 40	N 120 P 120**46** K 120	N 180 P 120 **40** K 120	N 180 P 80 **34** K 120	N 0 P 0 **28** K 0	N 120 P 80 **22** K 80	N 60 P 80 **16** K 80	N 180 P 80 **10** K 80	N 120 P120 **4** K 80
	N 180 P 80 **69** K 40	N 120 P 80 **63** K 40	N 120 P 40 **57** K 40	N 0 P 0 **51** K 0	N 0 P 80 **45** K 80	N 180 P 120 **39** K 80	N 180 P 120 **33** K 40	N 60 P 40 **27** K 80	N 120 P 80 **21** K 0	N 120 P 40 **15** K 80	N 180 P 40 **9** K 40	N 0 P 0 **3** K 0
FYM 10 t ha^{-1}	N 120 P 120 **68** K 80	N 60 P 80 **62** K 80	N 120 P 40 **56** K 80	N 180 P 80 **50** K 80	N 180 P 80 **44** K 40	N 120 P 80 **38** K 120	N 120 P 80 **32** K 40	N 60 P 80 **26** K 40	N 180 P 80 **20** K 120	N 180 P 120 **14** K 80	N 0 P 80 **8** K 80	N 180 P 120 **2** K 120
	N 0 P 0 **67** K 0	N 180 P 40 **61** K 40	N 120 P 80 **55** K 80	N 120 P 80 **49** K 0	N 120 P 0 **43** K 80	N 120 P 40 **37** K 40	N 60 P 40 **31** K 40	N 0 P 0 **25** K 0	N 60 P 40 **19** K 80	N 180 P 120 **13** K 40	N 0 P 0 **7** K 0	N 120 P 120 **1** K 120

5 m; **4 m**

Net plot size 5.0m * 4.0m = 20 sq.m.

- **Gate**

3.5.1 Field preparation

The experimental field was ploughed two times by tractor drawn cultivator followed by puddled through puddler and levelled.

3.5.2Method of transplanting

Rice was transplanted by using SRI method. Row to row and plant to plant distance was 25 cm. Single seedling of rice with two leaves stage (when plants were 10-12 days old) were transplanted in each hill in square grid pattern at a distance of 25 cm.

3.6 Soil analysis for nutrient status of experimental plots

Soil samples were collected from the surface (0-15 cm) of the experimental field before the creation of fertility gradients and analyzed the various physico-chemical properties of the field. After creation of fertility gradients, soil samples were again collected from each strip and analyzed the variation in the fertility gradient in the strips.

Final surface soil samples were collected from each plot of the experimental field before the application FYM and 24 selected fertilizer treatments and were analyzed for calculation of basic parameters. following methods were used for the analysis of the soil.

3.6.1 pH

20 gm of soil is taken and 50 ml of distilled water is added. The soil pH was determined by using ”electric glass electrode pH meter method” by keeping 1:2.5 soil water suspension and stirring it for 30 minutes as suggested by Piper (1966).

3.6.2Electrical conductivity (dS/m^2)

20 gm of soil is mixed with 50 ml of distilled water and was allowed to settle down for 1 day and then the conductivity of the liquid was determined by using

“conductivity bridge” as described by Black (1965). Standard KCL solution is used for calibration of instrument.

3.6.3 Cation exchange capacity

“Neutral normal ammonium acetate method” was used for determination of the cation exchange capacity as given by Black (1965). 1M ammonium acetate of pH 7.0 is used for CEC measurement.

3.6.4 Organic carbon

The organic carbon analysis of soil was carried out by using “Walkey and Black’s rapid titration method”. (1934). The oxidisable matter in the soil is oxidized by 1N $K_2Cr_2O_7$. The reaction is helped the heat created when two volumes of H_2SO_4 are blended with one volume of dichromate. The rest of the dichromate is titrated with ferrous sulphate. The solution received is inversely related to the measure of C present in soil sample.

3.6.5 Mechanical analysis

“International pipette method” as given by Piper (1966) was used for determination of sand, silt and clay content to know the textural class of experimental soil.

3.6.5 Available nitrogen

The “alkaline permanganate method” was used for determination of available nitrogen as described by Subbiah and Asija(1956). The soil is distilled with alkaline permagnate solution which gives ammonia. The available nitrogen in ammonia form is estimated by using KEL plus nitrogen distillation system using $KMnO_4$ and NaOH. Gaseous ammonia dissolved in boric acid were titrated against 0.01N sulphamic acid.

3.6.6 Available phosphorus

The available potassium was analyzed by "Olsen's method" as described by Olsen *et al*(1954). 0.5M Sodium bicarbonate ($NaHCO_3$) OF pH 8.5 is used as an extractent in this method The readings are taken in a 882 nm wavelength using an spectrophotometer.

3.6.7 Available potassium

The "normal ammonium acetate method" was used for determination of available potassium as described by Muhr *et al.* (1965). 1 N ammonium acetate of pH 7 is used for estimation. Reading is taken by using flame photometer.

3.7 Observations recorded

The plant observations were taken at the maturity stage just before harvesting of crop.

3.7.1 Plant Growth parameters–

- Plant Height (cm)
- No. of effective Tillers/hill

3.7.2 Yield attributing parameters-

- Test weight(gm)
- Grain and straw yield

3.8 Plant analysis for uptake study

The grain and straw samples were collected separately from each plot during the harvesting stage of rice. Collected samples were air dried and uniformly grinded for the analysis. Nitrogen, phosphorous and potassium content in grain and straw were determined by following methods.

3.8.1 Nitrogen content (%)

The nitrogen content in grain and straw was analyzed separately by using the method described by Chaapman and Pratt (1961). Half gram grinded sample with one gram of salt mixture (K_2SO_4 and $CuSO_4.5H_2O$ in the ratio of 10:1) was taken in the digestion tube. 10 ml of the concentrated H_2SO_4 acid was added and digested at 350^0C till the material become colourless Afterwards the nitrogen content in digested material was distilled by automatic KEL plus unit using $KMnO_4$ and NaOH. Gaseous ammonia dissolved in boric acid was titrated against 0.01N sulphamic acid.

3.8.2 Phosphorus and potassium content (%)

The grain and straw sample were digested separately by using di-acid mixture (concentrated HNO_3 and $HClO_4$ is taken in the ratio of 9:4. This material was digested at 150^0C until the material becomes colourless. The digested materials were transferred in 100 ml volumetric flasks than make upped the volume with distilled water and used for the estimation of P and K content.

The phosphorus content was analyzed by using “vanado-molybdate yellow colour complex method” as given by Jackson (1973). Five ml aliquot from 100 ml digested material was taken in 50 ml volumetric flask than 10 ml of vanado-molybdate yellow reagent was added and make upped he volume. The colour intensity was measured by using spectrophotometer at 420 nm.

The potassium content (%)in plant was determined by using “flame photometer” as described by Chapman and Pratt (1961). The K content in the grain was determined directly from 100 ml digested material using flame photometer whereas 5 ml digested straw aliquot was diluted in 25 ml volumetric flask for determination of potassium.

3.9 Analysis of FYM for NPK content

Oven dried FYM sample was digested and NPK content were determined for study of contribution of nutrients. The NPK content of organic manure (FYM) was 0.4%N, 0.3%P, 0.8%K respectively.

3.10Calculation of Basic parameters

Based on the analysis of soil test value of initial soil sample and uptake of NPK in kg ha $^{-1}$ from grain and straw some of the basic parameters are calculated as below:

3.10.1. Nutrient requirement (NR)

a) Kg N required per quintal grain production =

$$\frac{\text{Uptake of N in kg ha}^{-1}\text{ from grain + straw}}{\text{Grain yield in q ha}^{-1}}$$

b) Kg P_2O_5 required per quintal grain production =

$$\frac{\text{Uptake of } P_2O_5 \text{ in kg ha}^{-1}\text{ from grain + straw}}{\text{Grain yield in q ha}^{-1}}$$

c) Kg K_2O required per quintal grain production =

$$\frac{\text{Uptake of } K_2O \text{ in kg ha}^{-1}\text{ from grain + straw}}{\text{Grain yield in q ha}^{-1}}$$

3.10.2 Per cent nutrient contribution from soil to total nutrient uptake (E_s)

a) Per cent contribution of N from soil =

$$\frac{\text{Uptake of N (kg ha}^{-1}\text{) from grain + straw from control plot}}{\text{Soil test value for available N(kg ha}^{-1}\text{) from control plot}} \times 100$$

b) Per cent contribution of P_2O_5 from soil =

$$\frac{\text{Uptake of } P_2O_5 \text{ (kg ha}^{-1}\text{) from grain + straw from Control plot}}{\text{Soil test value for available } P_2O_5 \text{ (kg ha}^{-1}\text{) from control plot}} \times 100$$

c) Per cent contribution of K_2O from soil =

$$\frac{\text{Uptake of } K_2O \text{ (kg ha}^{-1}\text{) from grain + Straw from Control plot}}{\text{Soil test value for available } K_2O \text{ (kg ha}^{-1}\text{) from control plot}} \times 100$$

3.10.3 Per cent nutrient contribution from fertilizer to total uptake (E_f)

(a) Per cent contribution of N from fertilizer =

$$\frac{\text{Uptake of N in kg ha}^{-1}\text{ From grain + straw} - \text{Soil test value for available N (kg ha}^{-1}) \times \text{Per cent contribution of N from soil /100}}{\text{Fertilizer N applied in kg ha}^{-1}} \times 100$$

(b) Per cent Contribution of P_2O_5 from fertilizer =

$$\frac{\text{Uptake of } P_2O_5 \text{ in kg ha}^{-1}\text{ from grain + straw} - \text{Soil test value for available } P_2O_5 \text{ (kg ha}^{-1}) \times \text{Per cent contribution of } P_2O_5 \text{ from soil /100}}{\text{Fertilizer } P_2O_5 \text{ applied in kg ha}^{-1}} \times 100$$

(c) Per cent contribution of K_2O from fertilizer =

$$\frac{\text{Uptake of } K_2O \text{ in kg ha}^{-1} \text{ from grain + straw} - \text{Soil test value for available } K_2O \text{ (kg ha}^{-1}) \times \text{Per cent contribution of } K_2O \text{ from soil}/100}{\text{Fertilizer } K_2O \text{ applied in kg ha}^{-1}} \times 100$$

3.10.4 Per cent nutrient contribution from FYM to total uptake (E_{FYM})

Per cent contribution of Nutrients from FYM (E_{FYM}) =

$$\frac{\text{Nutrient uptake in Kg ha}^{-1} \text{ from grain + straw from only FYM treated plot} - \text{Nutrient uptake in kg ha}^{-1} \text{ from grain + straw from control plot}}{\text{FYM applied in kg ha}^{-1}} \times 100$$

.

3.10.5 Yield targeting equations

Troug (1960) given the introductory concept of evaluation of fertilizer prescription for targeted crop yield depended on available nutrient status. The theoretical basis of Liebig's law of minimum was established by Ramamoorty *et al.* (1967) in India which works fairly well for wheat opposite to the trust that it is justified only for N alone and not for P and K, which are not expected to pursue the percentage sufficiery concept of Mitscherlich and Baule (1961). These uncovered that the connection between grain yield and nutrient uptake was straight. For getting a specific yield nutrient in a particular amount needs to be taken by the plant. Once this is known, the fertilizer that should be applied can be evaluated by considering the efficiency of contribution from soil accessible nutrients and the effectiveness of uptake from applied fertilizer nutrients towards absolute take-up of the nutrients. This structures the reason for fertilizer recommendations for target yield of a crop.

The yield targeting equations were calculated from the above parameters as given below:

$$FN = \left(\frac{NR}{E_f} \times Y\right) - \left(\frac{Es}{E_f} \times SN\right) - \left(\frac{E_{FYM}}{E_f} \times FYM\ (t\ ha^{-1})\right)$$

$$F\ P_2O_5 = \left(\frac{NR}{E_f} \times Y\right) - \left(\frac{Es}{E_f} \times 2.29 \times SP\right) - \left(\frac{E_{FYM}}{E_f} \times FYM\ (t\ ha^{-1})\right)$$

$$F\ K_2O = \left(\frac{NR}{E_f} \times Y\right) - \left(\frac{E_s}{E_f} \times 1.21 \times SK\right) - \left(\frac{E_{FYM}}{E_f} \times FYM\ (t\ ha^{-1})\right)$$

Where,

FN = Fertilizer N (kg ha^{-1})

F P_2O_5= Fertilizer P_2O_5 (kg ha^{-1})

F K_2O = Fertilizer K_2O (kg ha^{-1})

NR=Nutrient requirement of N or P_2O_5 or K_2O kg q^{-1}produce.

SN= Soil test value for available N (kg ha^{-1})

SP= Soil test value for available P (kg ha^{-1})

SK= Soil test value for available K (kg ha^{-1})

Y=Yield target(q ha^{-1})

FYM=Farm yard manure (tha^{-1})

E_s=Soil's contribution in percentage

E_f= Fertilizer's contribution in percentage

E_{FYM}=FYM's contribution in percentage

3.11 Interpretation of soil test in terms of quantity of fertilizer

Yield targeting equation or fertilizer adjustment equation as recommended previously derived from the linear response and plateau consideration in the form of equation as given by Goswami *et al*.1986, Randhawa and Velayutham, 1982, Velayutham, 1979 and Velayutham *et al*. 1985 as,

$$F = \frac{NR}{E_f} \times Y - \frac{Es}{E_f} \times S - \frac{E_{FYM}}{E_f} \times FYM$$

Considering the basic equations calculation, fertilizer adjustment equations were inferred.

3.12 Statistical Analysis

The standard regression procedure was utilized to co-relate the soil test and fertilizer with crop yield response. The nutrient requirement, soil and fertilizer efficiencies were assessed by the STCR software created from the All India Coordinated Research Project on ”Soil Test Crop Response Correlation", Indian Institute of Soil Science, Bhopal.

CHAPTER V
RESULTS AND DISCUSSION

This section introduces the results of analysis carried out on "Calibration of soil test fertilizer dose and crop yield with and without FYM for hybrid rice under SRI in *Vertisol* of Chhattisgarh plains" in research farm of "College of Agriculture", Raipur, I.G.K.V. (C.G.) during *Kharif* season of 2018-19. The various parameters were analyzed and the results obtained are discussed below under following heads

4.1 Soil test levels by creation of fertility gradient

4.2 Soil nutrient status

4.3 Response of rice crop to added nutrients

4.4 Relationship between yield and nutrient uptake

4.5 Nutrient requirement for rice crop

4.6 Efficiencies of fertilizer, soil test and FYM

4.7 Estimation of fertilizer adjustment equations

4.8 Ready reckoners chart for fertilizer recommendations in SRI rice

4.9 Plant growth and yield parameters

4.1 Soil test levels by creation of fertility gradient

Soil fertility variations were intentionally created according to the methodology proposed by Ramamoorthy (1967) by including graded fertilizer doses (Table 4.1). During the summer season, 2018 maize was planted as exhaust crop for normal transformation of added nutrients into the soil complex. The fodder maize yield in different fertility strips showed that the fertility level gradient exists. Soil was analyzed from each fertility strip after harvesting of maize crop. Yield of Maize and soil test information (Table 4.1) demonstrated that soil test value variations of N (Alkaline $KMnO_4$-N) was little , with respect to N no gradient was created due to the dynamic nature of N in the soil further more, its various forms are lost through the processes "leaching, volatilization and nitrification". The fertility gradient was quite significant with respect to P due to the immobile nature of P. It gets fixed in the soil where particularly phosphorus is high in *vertisols*. Phosphorus ions reacts very rapidly with soil constituents for formation of compounds which are insoluble relying upon the nature of soils nature and subsequently stays in soil. Similar levels of soil test potassium was seen in all strips due to higher K status of the experimental fields soil and conservation of its dynamic harmony.

Table 4.1: Pre requisite fertilizer doses given in various strips for creating fertility gradient in the field and maize fodder yield during summer season of 2018

Fertility strips	Fertilizer doses (kg ha^{-1})			Fodder yield of maize	Post harvest soil test values (kg ha^{-1})		
	N	P_2O_5	K_2O		SN	SP	SK
L_0	0	0	0	19.10	226.0	11.27	469.5
L_1	100	75	50	21.81	233.0	17.56	483.0
L_2	200	150	100	26.48	238.5	26.96	488.5

4.2 Soil nutrient status

Just before coordinating the main experiment soil samples were drawn from each plot and examined for determination of nutrient status of soil as available nitrogen (N), phosphorus (P) and potassium (K). Table 4.2 shows the range and mean value of available nutrients viz. N, P and K kg ha^{-1} of the experimental plots.

The mean values of available N of the experimental plots varied from 202.72 to 220 kg ha^{-1}. Available P level recorded in the range of 14.77 to 25.68 kg ha^{-1}.Correspondingly the mean value of available K varied from 475.82 to 500.37 kg ha^{-1} (Table 4.2).

The available N, P and K values showed variation among fertility strips however the variation in available N and K levels with change in fertility strips were marginal whereas the variation in available P level in different strips were quite significant (Table 4.2) and it showed an increase as per fertility strips from L_0 to $L_{2.}$ The immobile nature of P and fixation with soil constituents for formation of compounds of insoluble nature depends on the nature of soil thus it remains in soil. The results showed formation of fertility gradient with respect to available P.

The level of available N and K do not form this type of gradient since the nature of N is very mobile and it declines in soil due to the processes like "runoff, leaching, volatilization and de-nitrification". The soil test value of available K of experimental soil was found to be in high level and maintenance of its dynamic equilibrium may have resulted in less variation on soil test potassium levels in all strips. Similar results were also reported by various researchers like Sharma *et al.* (2015), Milapchand *et al.* (2006) and Mahajan *et al.* (2013).

Table: 4.2 Range and mean values of soil nutrient status (kg ha^{-1}) in fertility strips of experiment before sowing of crop.

Soil Nutrients	**L_0**	**L_1**	**L_2**	**S.D.**	**C.V.(%)**
Alkaline KMnO4-N	176.2- 208.8 (202.72)	196.6-229.9 (216.6)	199.5- 229.9 (220)	12.43	5.83
Olsen's P	7.88- 17.16 (14.77)	14.86-29.39 (22.49)	21.32- 30.28 (25.68)	5.87	28.00
Neutral normal Ammonium Acetate extractable K	428.74-476.9 (475.82)	464.58-518.34 (488.87)	448.90-536.26 (500.37)	22.39	4.58

4.3 Response of rice crop to added nutrients

The range and mean yield of hybrid rice (IRH-103) presented in table 4.3 with regarding to three fertility strips. The results showed from L_0 to L_2 strip an increasing trend in grain yield. The grain yield of rice increased with respect to fertility gradient it might be due to the fertility gradient created for available P in soil status from L_0 to L_2.

Table no.-4.3 Range and mean value of grain yields (q ha^{-1}) of rice in relation to fertility strips .

Crop	**L_0**	**L_1**	**L_2**
Rice (IRH-103)	32.00-91.55 (68.31)	37.00-94.00 (72.27)	41.20-93.00 (75.18)
S. D.	18.95	19.41	17.46
C.V. (%)	27.75	26.85	23.22

The response of SRI rice (In terms of grain yield q ha^{-1}) to fertilizer N, P, K and FYM has been showed in graph 4.1 to 4.4. Rice crop responses to the N and P fertilizer was good whereas the response to K fertilizer was comparatively less consistent. FYM application response it the form of nutrients source was not quite marked by the crop as shown in graph (Fig.4.4). "Mahendar Kumar *et al*. (2009), Pandey *et al*. (2009), Singh *et al.* (2009) and Banerjee and Pal (2009)" already resulted on responses of various crops to applied N, P, K and FYM.

The relations between rice yields and various plant nutrients acting as independent variable were acquired by the use of regression analysis for evaluation of the yield variation due to various nutrients as given in table 4.4. The higher variation in grain yield of SRI rice was accounted for N alone as showed by the results. "Higher crop responses (R^2=0.846) were assigned to the high N requirement and due to its mobile nature, it is accessible to the plant in the root system sorption zone (Ramamoorthy *et al*., 1967)". The remaining variation in the yield was caused by fertilizer P_2O_5 and K_2O. The insoluble compounds are formed by P ions by its reaction with soil constituent hence they are immobile in soil. Results revealed that the rice crop showed less requirement of P nutrient as compared to N. Rice yield responses curvilinear nature to P application also did not get reflected on yield variation because of the poor R^2 value as compared to linear relationship. The yield variation caused due to FYM application was also seen to have very poor correlation. The combination of fertilizer N and fertilizer P was highly responsive to the yield as showed by the equation. (Table- 4.4) In Figure 4.1 the higher value R^2 (regression coefficient) shows higher correlation between yield and nutrient (N) .

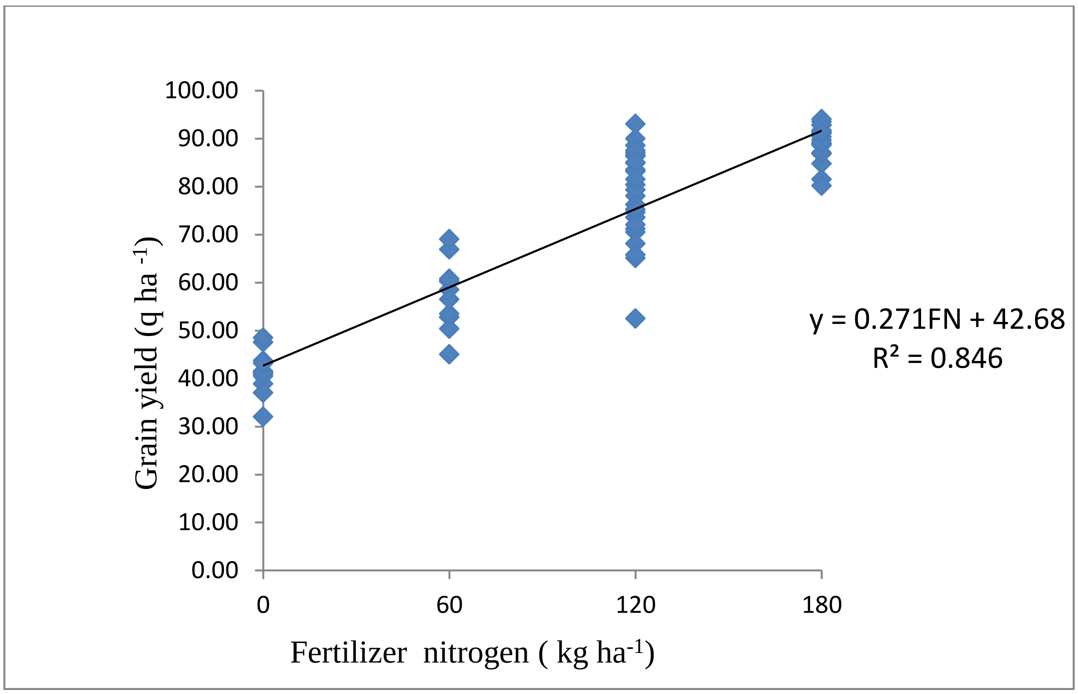

Fig.4.1 Response of Rice (grain yield) to added fertilizer nitrogen (kg ha^{-1})

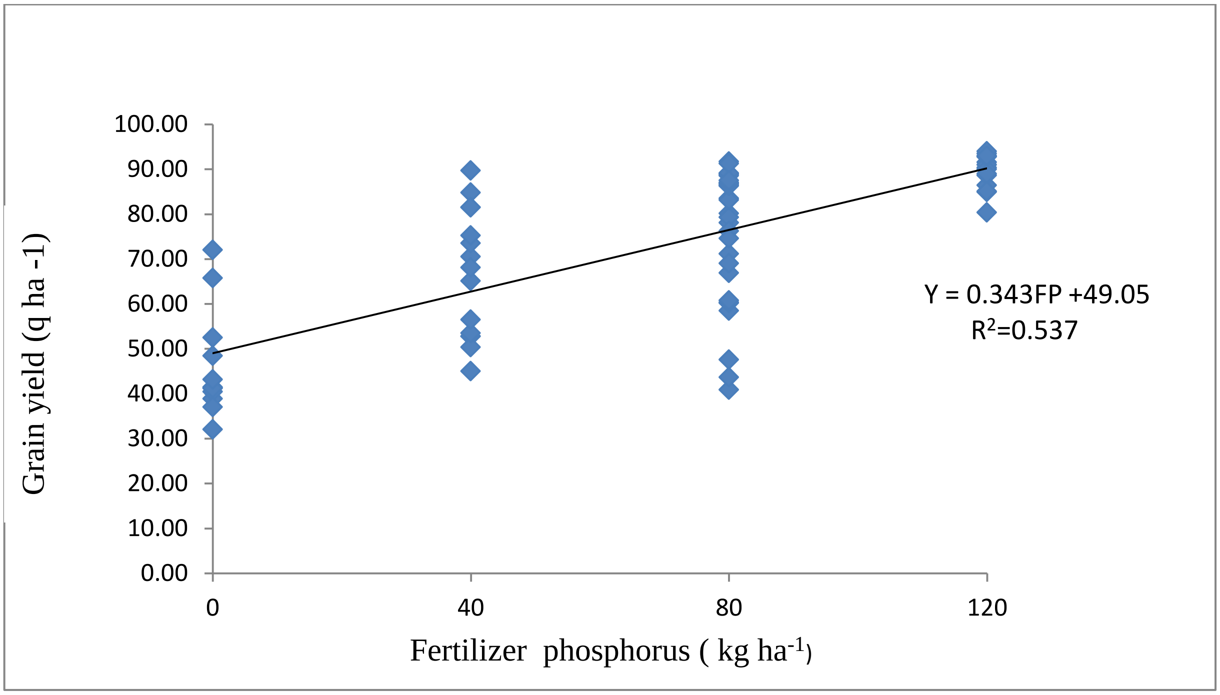

Fig.4.2 Response of rice (Grain yield) to added fertilizer phosphorus(kg ha^{-1})

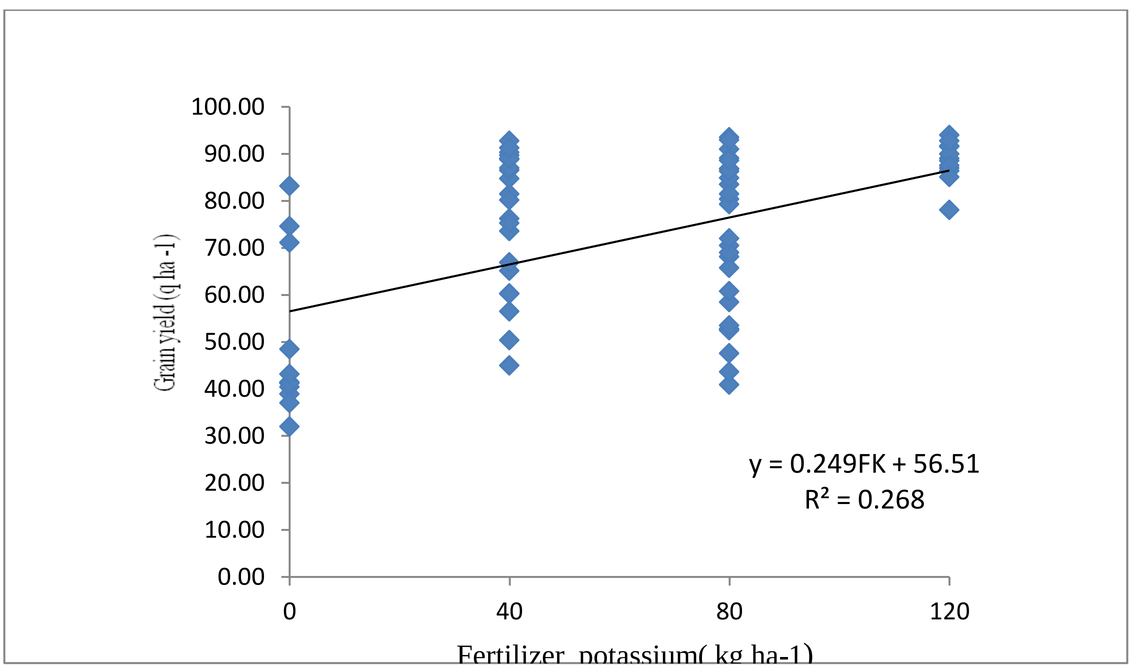

Fig.4.3 Response of rice (Grain yield) to added fertilizer potassium (kg ha^{-1})

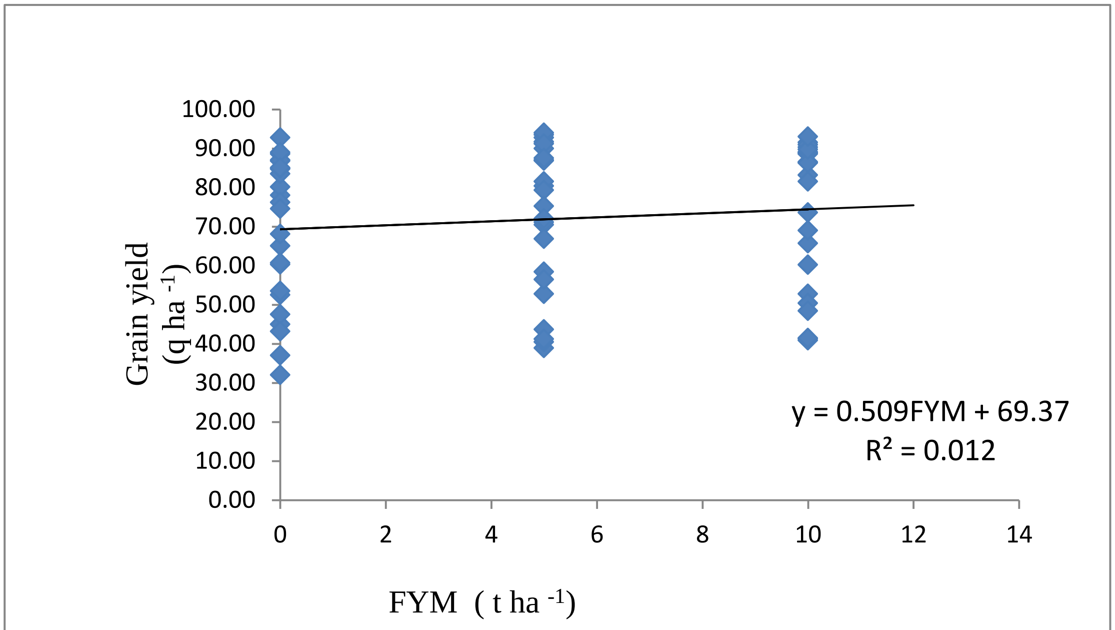

Fig.4.4 Response of rice (Grain yield) to added FYM (kg ha^{-1})

Table 4.4: Selected regression model to account for yield variation of rice.

S.No.	**Model for SRI rice**	**R^2**
1.	Y= 42.68 + 0.271FN	0.846
2.	Y = 49.05 + 0.343FP	0.537
3.	Y = 56.51 + 0.249 FK	0.268
4.	Y = 69.37+ 0.509 FYM	0.012
5.	Y= 38.90 + 0.22FN + 0.14FP	0.905
6.	Y=40.64 + 0.25FN + 0.06FK	0.850
7.	Y=46.90 +0 .30FP + 0.08FK	0.557
8.	Y=53.96 + 0.25FK + 0.51FYM	0.281
9.	Y=40.14+0.27FN+0.51FYM	0.859
10.	Y=46.50+0.34FP+0.51FYM	0.550

11.	Y = 38.59 + 0.22FN + 0.13FP+ 0.015FK	0.906
12.	Y =36.04 + 0.22FN + 0.13FP + 0.014FK + 0.51FYM	0.918
13.	Y=35.47 +0.76SP + 0.31FP	0.590
14.	Y= -81.67 + 0.18SK + 0.29FK	0.360
15.	Y= -16.87 + 0.29SN + 0.26FN	0.886
16	$Y=47.91 + 0.27\ FN - 0.0003\ FN^2$	0.860
17	$Y = 50.32 + 0.59\ FP - 0.0015\ FP^2$	0.570
18	$Y = 57.47 + 0.43\ FK - 0.003\ FK^2$	0.290
19	$Y = 75.93 - 0.28\ FYM + 0.07\ FYM^2$	0.018

Where,

"FN, FP and FK" represents the N, P_2O_5 and K_2O (kg ha^{-1}) given in fertilizer form. FYM represents "Farm Yard Manure "(t ha^{-1}). "SN, SP and SK" represents the NPK values of soil test."Y" represents crop yield. (q ha^{-1}).

4.4 Relationship between yield and nutrient uptake

The hybrid rice crop yield showed close interrelation with total uptake of N, P and K. Nutrient requirement for rice crop was estimated by using this relation (Table-4.5). Nutrient requirement can be defined as "the amount of nutrient (kg) required to produce per unit amount of yield. The nutrient requirement can be given by using the regression coefficient (b_1) of yield (Y) and total nutrient uptake (U)".

$$\mathbf{Y = b_1 U \text{ or } U = 1/b_1 * Y}$$

Where, $1/b_1$ gives the NR.

Table 4.5: Relation of rice yield (Y) with total nutrient uptake (U)

Nutrient	**SRI hybrid Rice**	
	Y = b1 U (NR*Uptake)	**R^2**
N	Y =1.59 UN	0.97
P	Y=0.88 UP	0.90
K	Y=0.91 UK	0.83

Table 4.5 showed that there is almost close linear relation observed between hybrid rice yield and total nutrient uptake. Relationship between nitrogen uptake and rice yield were found highest nearly one (R^2=0.97) among the N,P and K uptake.

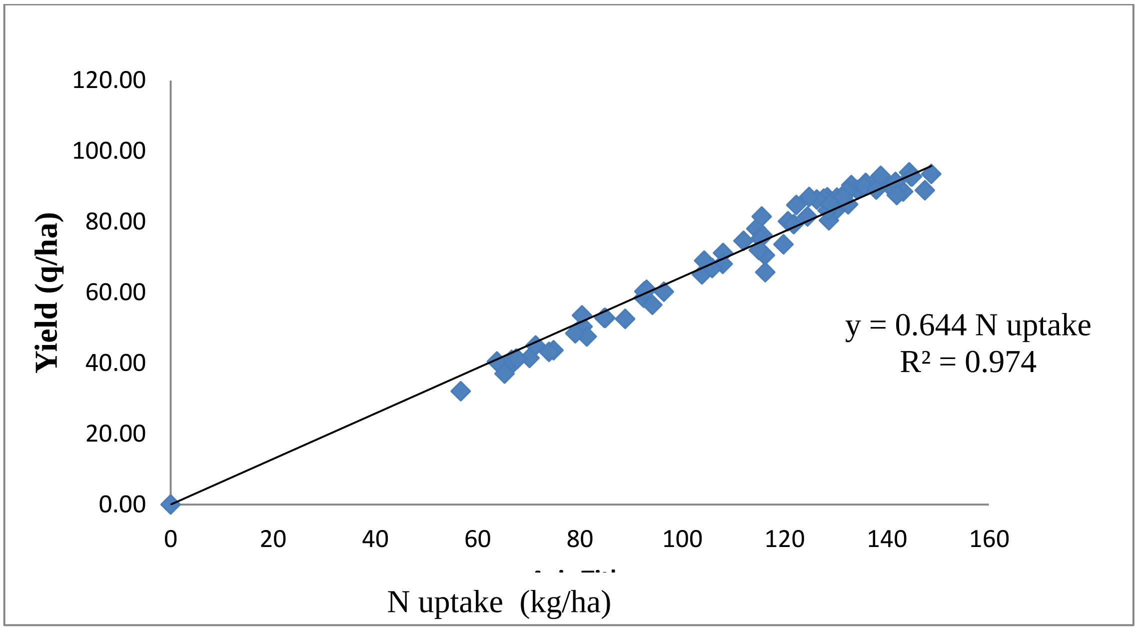

Fig.4.5 Relationship between rice grain yield and N nutrient uptake

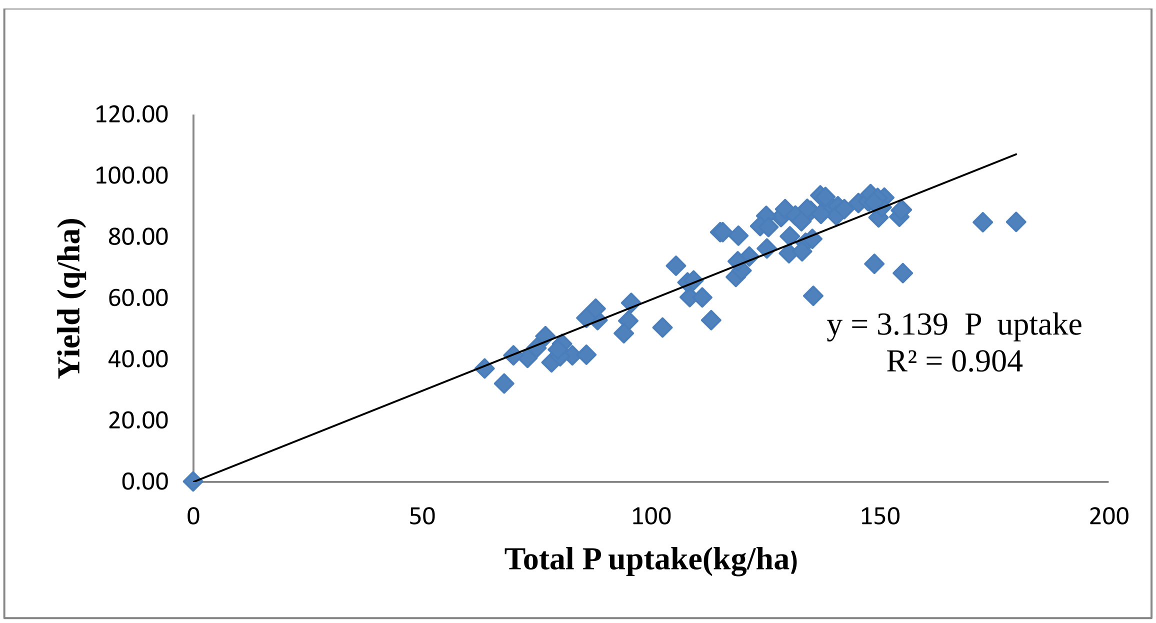

Fig.4.6 Relationship between rice grain yield and P nutrient uptake

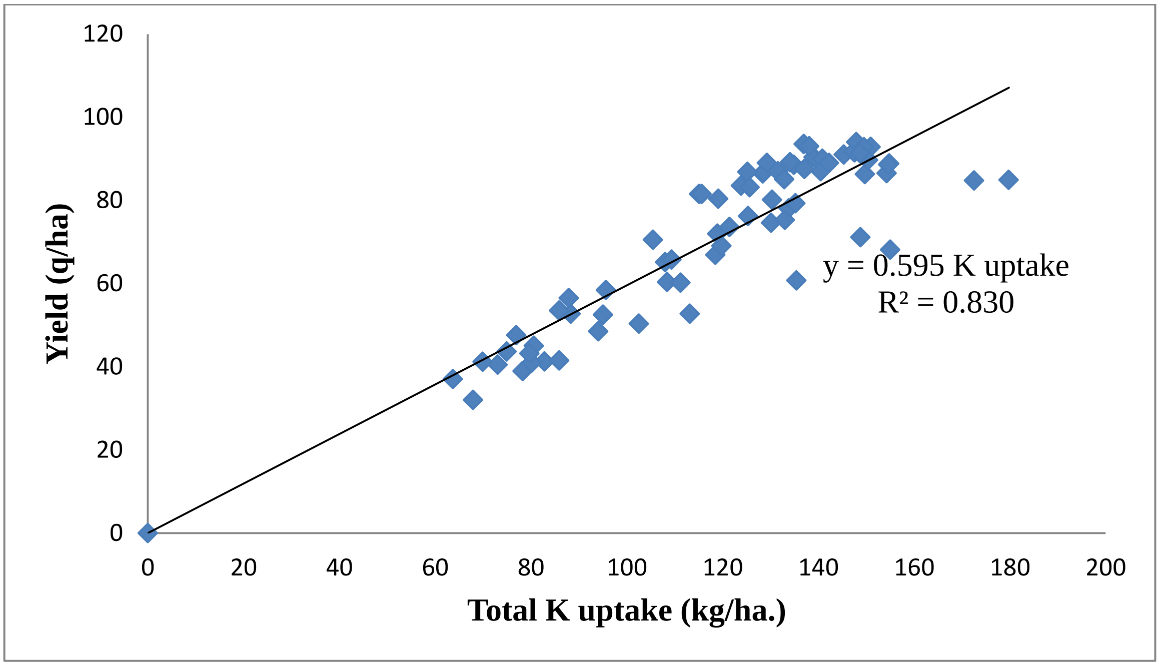

Fig.4.7 Relationship between Rice grain yield and K nutrient uptake


FYM
10t/ha
N P K
60·40·80
N P K
180·120·40
Ł0


FYM
10t/ha
N P K
120 0 80
N P K
120 40 40
Ł1


FYM
10t/ha
N P K
60·40·40
N P K
0 0 0
Ł1

Fig.4.8 Some views of rice crop experimental field

4.5 Nutrient requirement for rice crop

The amount of biomass production is directly related to the amount of nutrient absorption by the crop. The conventional and regression models were used for estimation of nutrient requirement of SRI hybrid rice. The above graphs show that there is a close relation between hybrid rice yield and its nutrient uptake almost close to a linear relationship. The amount of nutrient required to produce one quintal of SRI hybrid (IRH-103) was found as 1.57 kg N, 0.32 kg P and 1.71 kg K (Table- 4.6). Similar trend for mean nutrients requirement earlier reported by AICRP on STCR, Raipur centre for various rice verities of different duration(Annual progress report 2008,2009,2010).The conventional method is also used for estimation of nutrient requirement as given below:

$$\text{NR (kg q}^{-1}\text{)} = \frac{\text{Total Nutrient Uptake (kg ha}^{-1}\text{)}}{\text{Grain Yield (q ha}^{-1}\text{)}}$$

Nutrient requirement for various crops has been reported by various scientists from time to time. Ramamoorthy *et al.* (1967) reported for producing one quintal of wheat grain the nutrient requirement was 2.5 kg N, 0.8 kg P_2O_5 and 1.0 kg K_2O. Srivastava *et al.* (2017) estimated that rice crop (var. Indira sona) required 1.52 kg N, 0.38 kg P and 2.03 kg K for production of one quintal grain yield. Sahu *et al*. (2017) worked on soil test crop response rice (c.v. Swarna) crop on *vertisol* at IGKV farm Raipur under integrated plant nutrient system and reported for production of one quintal of rice grain nutrient requirement was found as 1.54 kg of N, 0.29 kg of P and 1.72 kg of K .

4.6 Efficiencies of fertilizer, soil test and FYM

The software developed by AICRP on STCR Indian Institute of Soil Science, Bhopal (MP) was used for calculation of contribution of nutrient from fertilizer, soil and FYM in term of percent efficiency of fertilizer, soil test and FYM (results given in the table 4.6). Efficiencies for N, P and K fertilizers were estimated as 39.87, 30.53 and 94.53 percent respectively. In same way the soil test efficiencies were recorded as 32.66, 73.38 and 16.39 percent NPK, respectively. The organic source (FYM) efficiency was found as 13.01%, 5.43% and 10.10 % for N, P and K respectively.

Table 4.6: Efficiencies (%) of fertilizer, soil test and FYM and nutrient requirement of SRI hybrid rice var.IRH-103 (kg ha^{-1})

Parameters	Rice		
	N	P	K
Soil test Efficiency (%) E_s	32.66	73.38	16.39
Fertilizer Efficiency (%) E_f	39.87	30.53	94.53
FYM Efficiency (%) E_{org}	13.01	5.43	10.10
Nutrient requirement (kg ha^{-1})	1.57	0.32	1.71

Due to various processes such as de-nitrification, volatilization, leaching,, and run-off approximately 2/3rd percent of the fertilizer nitrogen applied was lost. A big part of the applied phosphorus gets fixed in the soil by reaction with dominant cations such as Fe, Mn, Ca, Mg etc present in soil. Efficiency of fertilizer K applied was recorded to be higher due to its greater uptake by plants as luxury consumption. The soil test efficiency was lower as compared to fertilizer efficiency for N and K but it was recorded to be higher for soil test P. Ramamoorthy *et al.* (1967), Shrivastava *et al*.(2017), Sahu *et al*.(2017), Regar and singh (2014), Parihar *et al*.(2015) also calculated efficiencies for soil, fertilizer and FYM respectively.

4.7 Estimation of fertilizer adjustment equations for SRI hybrid rice

The basic parameters such as "nutrient requirement, efficiencies of fertilizers, soil test and organic source (FYM)" were used to evolve fertilizer adjustment equations for SRI hybrid rice crop for achieving a definite yield goal. equations were evolved by using these basic parameters for adjustment of fertilizer N, P_2O_5 and K_2O in SRI hybrid rice crop (var.IRH-103) are given as Follows:

Table 4.7 Fertilizer prescription equations derived for SRI hybrid rice (var.IRH-103).

Fertilization	Fertilizer prescription equations
NPK + FYM	FN = 3.93Y - 0.82 SN - 0.33 FYM
	FP_2O_5 = 1.03 Y - 1.03 SP - 0.18 FYM
	FK_2O= 1.81 Y - 0.17 SK - 0.11 FYM

Here,

"FN, FP and FK" represents the N, P_2O_5 AND K_2O (kg ha^{-1}) given in fertilizer form. FYM represents "Farm Yard Manure "(t ha^{-1}). "SN, SP and SK" represents the NPK values of soil test. "Y" represents crop yield. (q ha^{-1}).

4.8 Ready reckoners chart for fertilizer recommendations in SRI rice

The ready reckoners chart has been prepared for recommendation of fertilizers (with FYM @ 5 t ha^{-1}) in SRI hybrid rice (var-IRH-103) as per the fertilizer adjustment equations derived from the experiment conducted.

The use of FYM resulted in reduction of the fertilizer needs since FYM also works as a source of nutrient. The integrated use of FYM and Fertilizer has shown many benefits which includes increase in soil fertility and improvement of the soils physical properties. It has been seen that fertilizer requirement is inversely related with soil test value hence as soil test value increases fertilizer requirement decreases. Hence it can be said that low yield target should be considered for an poor farmer with less resources to get maximum amount of profit per unit cost whereas for rich and resourceful farmers higher yield target should be used so that he can obtain maximum potential yield from per unit of the land. Hence yield target should be chosen appropriately and it should be complimented with balanced fertilizer dose to achieve objectives such as maintain soil fertility as well as high grain yield.

Table 4.8: "Ready reckoners for fertilizer N P and K recommendations based on soil test levels with 5 tons of FYM for SRI Rice (IRH-103) in *Vertisols* of Chhattisgarh"

Soil Test Values			**Yield Target of Rice (q/ha)**								
(kg ha^{-1})			**65 (q ha^{-1})**			**75 (q ha^{-1})**			**85 (q ha^{-1})**		
SN	S P	SK	FN	FP	FK	FN	FP	FK	FN	FP	FK
150	4	200	131	62	83	171	72	101	210	83	119
175	6	225	111	60	79	150	70	97	190	80	115
200	8	250	90	58	75	130	68	93	169	78	111
225	10	275	70	56	70	109	66	88	149	76	107
250	12	300	49	54	66	89	64	84	128	74	102
275	14	325	29	52	62	68	62	80	108	72	98
300	16	350	8	50	58	48	60	76	87	70	94
325	18	375	8	48	53	27	58	71	67	68	90
350	20	400	8	45	49	7	56	67	46	66	85
375	22	425	8	43	45	7	54	63	26	64	81
400	24	450	8	41	41	7	52	59	5	62	77

Where

"FN, FP and FK" represents the N, P_2O_5 and K_2O (kg ha^{-1}) given in fertilizer form. FYM represents "Farm Yard Manure "(t ha^{-1}). "SN, SP and SK" represents the NPK values of soil test. "Y" represents crop yield. (q ha^{-1}).

4.9 Plant growth and yield parameters

4.9.1 Plant growth parameters

Plant height results of (Table 4.9) showed an increase as we go from L_0 to L_2. In the fertility strip L_0 plant height varied in the range of 110.7 cm to 135.7 cm with an average of 123.26 cm. In the fertility strip L_1 Plant height were in the range of 120.1 cm to 137.1 cm with an average of 130.3 cm whereas in the fertility strip L_2 plant height varied between 126.6 to 143.1 with an average of 135.87 cm.

Similarly panicle length also increased from L_0 to L_2. In L_0 panicle length were observed in between 26.1 cm to 29.8 cm with an average of 28.02 cm. In L_1 panicle length were from in the range of 26.4 cm to 30 cm with an average of 28.57 cm. In L_2 panicle length ranges between 27.5 cm to 30.3 cm with an average of 28.59 cm.

Table 4.9: Range and mean of plant height and panicle length (c.m.) in fertility strips of experiment.

Parameters	**L_0**	**L_1**	**L_2**
Plant height	110.7-135.7 (123.26)	120.1-137.1 (130.3)	126.6-143.1 (135.87)
Panicle length	26.1-29.8 (28.02)	26.4-30 (28.57)	27.5-30.3 (28.59)

4.9.2 Yield parameters

The yield parameters showed close relation with the grain yield of rice. The grain yield as well as yield parameters increased as we go from L_0 to L_2 (Table 4.2 and Table 4.10). Number of effective tillers in L0 varied between 10.4 cm to 17.5 cm with an average of 13.82 cm. In L_1 numbers of effective tillers were in the range of 14 to 21.3 with an average of 17.77. Similarly in L_2 the effective tillers were between 17.8 to 22.2 with an average of 20.64 cm.

Weight of rice grain is one of the most important factor affective amount of grain yield received . Test weight of rice in L_0 strip were between 22.1 gm to 28.7 gm with mean of 25.94 grams. In L_1 strip it varied in the range of 22 gm to 28.5 gm with an average of 26.1 grams. In L_2 strip it was between 23.8 to 28.8 with an average of 26.93gram. All the yield and growth parameters supported the higher yield in higher fertility strips.

Table 4.10 Range and mean of Yield parameters in fertility strips of experiment.

Parameters	**L_0**	**L_1**	**L_2**
No. of Effective tillers (per hill)	10.4-17.5 (13.82)	14-21.3 (17.77)	17.8-22.2 (20.64)
Test weight (in gm)	22.1-28.7 (25.94)	22-28.5 (26.1)	23.8-28.8 (26.93)

CHAPTER V
SUMMARY AND CONCLUSIONS

An experiment was conducted at instructional farm of I.G.K.V., Raipur (C.G.) during *Kharif* season of 2018 to study "Calibration of soil test, fertilizer dose and crop yield with and without FYM for hybrid rice under SRI in *Vertisol* of Chhattisgarh plain" with the objectives-

1. Evaluating response of the hybrid rice to added fertilizers (NPK) and FYM.
2. Estimation of requirement of NPK by hybrid rice
3. Evaluation of efficiencies (soil test, fertilizer and FYM efficiencies) for hybrid rice in *Vertisol*
4. Derivation of "soil test based fertilizer prescription equation" for hybrid rice.

A special field method – "Inductive cum targeted yield model"- for soil test crop response study evolved by Ramamoorthy *et al.* (1967) was utilized in this experiment. "Re-enforced resolvable block design" was used for experiment.

First of all, three equal sized vertical fertility strips (replication) of low (L_0), medium (L_1) and high (L_2) fertility levels were created in the experimental field. All the strips were further divided into three equal parts (blocks) for 3 doses of FYM "0, 5 and 10 t ha-1", hence total 9 blocks had been there in the experimental area. Each block was further categorized into 08 equal plots. Total 24 treatment combinations comprise of four different doses of N with "0, 60, 120 and 180 kg ha^{-1}", P_2O_5 with "0, 40, 80 and 120 kg ha^{-1}" and K_2O with "0, 40, 80 and 120 kg ha^{-1}" were selected and given as fertilizer treatments. These 24 treatment combinations were again divided in to three groups of eight treatments (A, B and C) and applied in each strip.

Soil samples were taken from each plot just before applications of the selected 24 treatments and were analyzed for available nitrogen, phosphorus and potassium status in the plots. The mean values of available N in the soils were found in the ranged from 202.72 to 220 kg ha^{-1}. Mean value of soil P ranged from 14.77 to 25.68 kg ha^{-1}. The mean available K value found ranged from 475.82 to 500.37 kg ha^{-1}. The values of available nitrogen, phosphorus and potassium in the soil varied in different fertility strips but it has been seen that variation of available nitrogen and potassium with different fertility strips were marginal whereas variation in available P value was quite marked and in different fertility strips increased from L_0 to L_2.

The hybrid rice grain yield productivity of overall 72 plots was recorded in the range of 32 to 93 q ha^{-1} with an average of 71.92 q ha^{-1}. The grain yield also showed an increasing trend from L_0 to L_2. The increasing trend in different fertility strips (replication) may be due to change in fertility gradient from L_0 (low) to L_2 (high).

Regression model showed that nitrogen and phosphorus explained 90.5% of the yield variation in hybrid rice and it showed that inclusion of fertilizer K had less contribution towards crop yield. Maximum yield variations has been seen when all the three major nutrients combined with FYM but it was at par with the yield variations when all three major nutrients were added without FYM. This showed that the contribution of FYM towards yield variation in hybrid rice was very less in the form of nutrient. It may be due to the slower nutrient releasing pattern of FYM.

For production of 1 quintal of hybrid rice the nutrient requirements were calculated as 1.57 kg, 0.32 kg and 1.71 kg of “N, P and K” respectively. Nutrient requirements of NPK were utilized for calculation of fertilizer requirements based on soil test value for achieving the targeted yield of hybrid rice. Relationship between nutrient uptake and grain yield was very close to linear.

The contributions from “N, P and K fertilizers” was determined as 39.87, 30.53 and 94.53 percent (efficiency of fertilizers), respectively. In same way the contribution from soil were recorded as 32.66, 73.38 and 16.39 percent (efficiency of soil test) for “N, P and K” respectively. The FYM contribution was calculated as 13.01, 5.43 and 10.10 percent (efficiency of FYM) for “N, P and K” respectively.

On the basis of the basic parameters viz. nutrient requirements and fertilizer, soil test and FYM efficiencies, the equations for Fertilizer prescription were evolved for SRI hybrid rice (Var. IRH-103).

Fertilizer prescription equations

Fertilization	**Fertilizer prescription equations**
NPK + FYM	FN=3.93Y - 0.82SN - 0.33FYM
	FP_2O_5=1.03Y - 1.03SP - 0.18FYM
	FK_2O=1.81Y - 0.17SK - 0.11FYM

Here

"FN, FP and FK" represents the fertilizer N, P_2O_5 and K_2O (kg ha^{-1}).

FYM represents "Farm Yard Manure "(t ha^{-1}).

"SN, SP and SK" represents the NPK values of soil test.

"Y" represents crop yield. (q ha^{-1}).

The ready reckoners chart was also prepared as per the derived equations for the recommendations of fertilizers application (with 5 tons of FYM) on the basis of soil test values. It can be used by farmers and extension workers at the field levels.

Derived fertilizer equations is very use full for soil testing laboratories for the recommendation of fertilizers on the basis of "soil test results" and amount of FYM to be incorporated in the field.

Conclusion:

It has been seen that the SRI hybrid rice (var.IRH-103) response to fertilizer N and P were good while its response to fertilizer K was very less. Response of the crop was depends on the level of nutrients in the soil. Crop response to FYM as a source of nutrients was not quite marked. Relationship between fertilizer N and hybrid rice yield was observed very close to linear.

Based on the basic parameters, "soil test based fertilizer adjustment equations" for a targeted grain yield of SRI hybrid were derived. Fertilizer recommendations can be calculated by using these equations (with FYM under IPNS) for SRI hybrid rice for the balanced nutrient application and sustainable farming.

SUGGESTIONS FOR FUTURE RESEARCH WORK:

- Developed fertilizer prescription equations and other information's gathered in this experiment can be tested in farmer's field with SRI method, hybrid rice or both with similar soil situation.
- Since demand of food grains is continuously increasing in India and since rice being the major food grain of India hence further research work is required for hybrid rice.
- Fertilizer prescription equations also should be developed for other major food grain crops.

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Appendices

Appendix-A

Table: Weekly meteorological data during crop growth period (07 July 2018 to 29 October 2018)

Week	Temperature		Rainfall (mm)	Relative humidity		Evaporation (mm day^{-1})	Sunshine (hours day^{-1})
	Max.. (°C)	Min. (°C)		RH I (%)	RH II (%)		
28	31.1	25	19.92	94.0	86.0	2.3	0.9
29	29.74	25.4	10.85	92.28	82.28	2.52	0.41
30	29.9	25.28	1	87.25	69.25	2.7	0.5
31	30.9	24.7	13.2	90.4	75.4	3.5	2.1
32	30.1	25.2	15.6	92.9	86.4	3.5	1.3
33	29.6	25.0	4.4	93.3	77.7	2.6	2.4
34	28.4	24.2	42.9	95.4	84.4	2.3	0.2
35	29.3	23.9	5.9	92.3	78.7	2.7	2.2
36	31.4	24.7	0.0	91.1	56.7	3.5	5.0
37	32.6	24.8	2.9	90.4	63.6	3.6	5.9
38	31.8	24.5	2.7	93.2	61.6	3.1	6.1
39	34.1	23.8	0.0	91.4	43.9	4.0	8.0
40	32.4	22.8	0.0	87.1	51.1	4.0	7.1
41	33.4	21.3	0.0	88.6	40.1	3.4	8.5
42	32.1	18.9	0.0	85.3	45.5	3.7	8.6
43	32.4	20.3	0.0	86.1	43.7	3.8	8.8
44	31.0	14.9	0.0	86.0	29.3	3.4	8.7

Appendix-B	
Soil test crop response data of rice	
Location : Instructional Farm, IGKV, Raipur	**Crop : Rice**
Soil Depth: 0-15 cm	**Variety : IRH-103**
Season:*Kharif*, 2018	**Soil Type :*Vertisols***

Table. Plot wise data for crop yield, nutrient uptake, soil test value, fertilizer doses and FYM applied

S.No	**Rice yield (q/ha)**	**Nutrient uptake (kg ha^{-1})**			**Soil test values (kg ha^{-1})**			**Fertilizer dose (kg ha^{-1})**			**FYM (q ha^{-1})**
		UN	**UP**	**UK**	**SN**	**SP**	**SK**	**N**	**P2O5**	**K2O**	
L0											
1	86.40	131.20	26.90	128.45	206.3	**17.74**	***500.42***	**120**	**120**	**120**	**10**
2	91.55	139.73	26.94	147.62	206.3	**18.64**	***516.10***	**180**	**120**	**120**	**10**
3	38.90	66.18	11.64	78.30	184.4	**13.78**	***463.22***	**0**	**0**	**0**	**5**
4	80.35	128.75	25.08	119.15	203.3	**15.95**	***485.86***	**120**	**120**	**80**	**5**
5	78.05	114.56	24.02	133.83	216.9	**14.16**	***474.66***	**120**	**80**	**120**	**0**
6	52.50	88.89	12.81	95.11	189.8	**9.68**	***455.62***	**120**	**0**	**80**	**0**
7	41.25	67.57	12.13	82.82	199.8	**14.68**	***470.10***	**0**	**0**	**0**	**10**
8	40.90	66.68	10.02	80.20	193.0	**14.16**	***497.06***	**0**	**80**	**80**	**10**
9	81.50	124.55	23.43	115.11	203.3	**13.26**	***474.66***	**180**	**40**	**40**	**5**
10	86.85	128.42	25.50	128.71	210.1	**16.84**	***493.70***	**180**	**80**	**80**	**5**

11	80.15	120.72	22.88	130.39	196.5	**15.95**	***482.50***	**180**	**80**	**40**	**0**
12	32.00	56.72	6.72	67.95	197.0	**7.88**	***428.74***	**0**	**0**	**0**	**0**
13	90.35	133.14	28.06	139.08	216.9	**19.53**	***511.62***	**180**	**120**	**40**	**10**
14	91.00	135.93	27.49	145.34	223.6	**18.64**	***515.30***	**180**	**120**	**80**	**10**
15	70.50	116.24	21.20	105.51	210.1	**13.26**	***463.46***	**120**	**40**	**80**	**5**
16	58.45	92.50	17.82	95.67	196.5	**13.26**	***452.26***	**60**	**80**	**80**	**5**
17	60.30	92.67	18.67	108.48	189.8	**14.16**	***451.14***	**60**	**80**	**40**	**0**
18	45.00	71.36	13.25	80.63	176.2	**13.44**	***446.66***	**60**	**40**	**40**	**0**
19	52.75	84.99	16.15	88.33	196.5	**15.05**	***460.10***	**60**	**40**	**80**	**10**
20	89.00	134.33	29.02	129.31	219.1	**17.74**	***511.62***	**180**	**80**	**120**	**10**
21	71.15	108.05	21.90	148.85	213.3	**13.26**	***462.34***	**120**	**80**	**0**	**5**
22	79.30	121.84	24.34	135.27	210.1	**15.95**	***475.78***	**120**	**80**	**80**	**5**
23	65.10	103.92	21.16	108.03	203.3	**13.26**	***462.34***	**120**	**40**	**40**	**0**
24	76.20	115.75	25.74	125.34	203.3	**14.16**	***464.58***	**120**	**80**	**40**	**0**
L1											
25	41.45	70.22	12.38	85.90	200.1	**14.86**	***472.06***	**0**	**0**	**0**	**10**
26	60.20	96.49	18.15	111.24	210.9	**15.32**	***474.66***	**60**	**80**	**40**	**10**
27	52.75	84.81	15.51	113.19	208.9	**15.74**	***486.98***	**60**	**40**	**80**	**5**
28	40.45	63.80	13.60	73.07	208.8	**22.22**	***482.50***	**0**	**0**	**0**	**5**
29	84.75	122.33	22.24	172.55	199.5	**17.16**	***462.34***	**180**	**40**	**40**	**0**
30	68.10	107.98	27.50	155.07	209.9	**17.74**	***486.98***	**120**	**40**	**80**	**0**
31	50.35	80.56	18.84	102.56	196.6	**15.95**	***471.30***	**60**	**40**	**40**	**10**
32	86.50	127.75	30.83	154.30	213.4	**21.32**	***489.22***	**120**	**80**	**40**	**10**
33	92.80	144.83	26.31	150.99	226.6	**24.01**	***488.10***	**180**	**120**	**40**	**5**
34	91.70	138.10	27.59	147.42	219.9	**29.39**	***484.74***	**180**	**80**	**120**	**5**
35	86.80	130.33	22.77	125.21	209.9	**21.32**	***484.74***	**180**	**80**	**80**	**0**
36	37.00	65.30	11.59	63.70	225.9	**22.22**	***486.98***	**0**	**0**	**0**	**0**

37	73.55	119.86	25.19	121.50	229.9	**27.60**	***513.86***	**120**	**40**	**40**	**10**
38	88.55	143.22	26.19	134.93	226.3	**28.18**	***518.34***	**120**	**80**	**120**	**10**
39	93.50	148.74	30.03	137.00	216.6	**24.01**	***473.54***	**180**	**120**	**80**	**5**
40	94.00	144.46	31.20	147.97	206.6	**23.12**	***491.46***	**180**	**120**	**120**	**5**
41	83.50	130.25	21.95	123.88	226.6	**20.43**	***484.74***	**120**	**80**	**80**	**0**
42	60.75	93.06	21.32	135.48	219.9	**21.12**	***480.26***	**60**	**80**	**80**	**0**
43	65.75	116.28	18.99	109.35	229.9	**23.80**	***514.98***	**120**	**0**	**80**	**10**
44	88.85	147.49	27.28	154.83	226.9	**28.08**	***516.10***	**180**	**80**	**40**	**10**
45	43.65	74.89	15.36	74.99	223.6	**26.49**	***500.42***	**0**	**80**	**80**	**5**
46	89.95	135.60	27.27	140.88	223.6	**28.18**	***513.86***	**120**	**120**	**120**	**5**
47	84.90	132.49	26.45	179.80	228.8	**27.60**	***486.98***	**120**	**120**	**80**	**0**
48	74.60	112.05	25.25	130.18	210.1	**24.01**	***467.94***	**120**	**80**	**0**	**0**
L2											
49	83.15	128.46	27.97	125.67	210.1	**24.01**	***500.42***	**120**	**80**	**0**	**10**
50	89.10	137.97	29.83	134.13	216.9	**23.12**	***521.70***	**180**	**80**	**80**	**10**
51	41.20	67.79	14.20	69.94	218.9	**23.12**	***489.22***	**0**	**0**	**0**	**5**
52	66.90	105.93	24.28	118.55	208.8	**22.22**	***464.58***	**60**	**80**	**40**	**5**
53	53.50	80.43	18.18	85.94	199.5	**21.32**	***482.50***	**60**	**40**	**80**	**0**
54	47.55	81.36	16.64	76.96	219.9	**30.28**	***510.50***	**0**	**80**	**80**	**0**
55	86.30	126.38	30.14	149.75	226.6	**27.60**	***514.98***	**120**	**80**	**80**	**10**
56	81.50	115.58	26.96	115.67	233.4	**30.28**	***536.26***	**120**	**40**	**80**	**10**
57	75.25	115.33	25.60	133.04	226.6	**28.49**	***519.46***	**120**	**40**	**40**	**5**
58	56.48	94.23	19.58	87.92	219.9	**23.12**	***486.98***	**60**	**40**	**40**	**5**
59	88.60	132.28	29.36	154.64	219.9	**30.08**	***508.26***	**180**	**120**	**80**	**0**
60	87.00	124.86	29.76	140.52	219.9	**30.28**	***510.50***	**180**	**80**	**120**	**0**
61	89.70	142.34	28.73	150.42	219.9	**22.22**	***508.26***	**180**	**40**	**40**	**10**
62	69.00	104.37	23.47	119.83	216.3	**24.01**	***480.26***	**60**	**80**	**80**	**10**

63	87.00	131.47	27.91	131.57	226.6	**28.49**	***500.42***	**120**	**80**	**40**	**5**
64	72.00	115.02	24.55	118.96	226.6	**27.60**	***502.66***	**120**	**0**	**80**	**5**
65	92.75	145.02	29.86	149.57	226.6	**24.91**	***520.58***	**180**	**120**	**120**	**0**
66	89.00	141.43	29.59	142.26	219.9	**26.70**	***493.70***	**180**	**120**	**40**	**0**
67	48.45	79.11	16.55	94.09	229.9	**20.43**	***503.78***	**0**	**0**	**0**	**10**
68	93.00	138.87	30.69	138.11	226.9	**30.28**	***508.26***	**120**	**120**	**80**	**10**
69	91.25	141.76	28.00	148.77	223.6	**25.80**	***476.90***	**180**	**80**	**40**	**5**
70	87.50	142.01	27.28	137.16	223.6	**29.39**	***525.06***	**120**	**80**	**120**	**5**
71	43.15	74.02	12.86	79.68	208.8	**18.64**	***448.90***	**0**	**0**	**0**	**0**
72	85.05	129.01	29.08	132.90	210.1	**24.01**	***494.82***	**120**	**120**	**120**	**0**

International Journal of Current Microbiology and Applied Sciences (IJCMAS) NAAS RATING-5.38, ICV-92.3

ISSN: 2319-7692 (Print) ISSN 2319-7706 (Online)

An International, **Monthly, Online, Free Access, Peer Reviewed,**
Indexed, **fast track** Scientific Research Journal

ACCEPTANCE LETTER

Ref #: 201909016– IJCMAS
Date: 21-08-2019

To

Anurag Gupta, Rakesh Banwasi, Dr. L.K. Srivastava, Gourav jatav

Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh), India

Sub: Acceptance of Manuscript - IJCMAS- 201909016– **reg.**

Dear Author(s),

It is pleasure to inform you that your manuscript No. 201909016-IJCMAS Entitled " **Calibration of soil test, fertilizer dose and crop yield with and without FYM for hybrid rice (Var.IRH-103) under SRI in Vertisol of Chhattisgarh plain**" has been accepted for publication in International Journal of Current Microbiology and Applied Sciences and published in the Vol 8 (09) to be released in September-2019.

Thank you

With Regards

Dr.M.Prakash
Editor-in-chief
International Journal of Current Microbiology and Applied Sciences
+91-9842641794
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