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Study of Integrated Crop-targeted Production Efficient Fertilizer Uptake Response

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The targeted pattern of multi-crops in investigation, control and treatment blocks emphasize on different crops or integrated approach to farming system in same field at temporal shift in cropping season. Studies and researches through programmes on "Integrated Farming System" paves and does incursion towards re-engineering process in plans and programme structure under farming systems mode. This gamut of framework led to neo institutional birth, through rigorous investigations of past models, approaches, plans, systems by analysis of productivity, viability and constraints prevailing. Designs of resource efficient, efficacious, economic farming system models and proto-modules for different farming scenario have been developed, in temporal dimensional shift of Kharif, Rabi and Zaid. Stoichiometric analysis-based use of balanced uptake fertilizers is done to meet the targeted productivity. Regression analysis and optimization models, equations, quasi-newton method and Jacobi method, amongst others , and conditions and constraints further give boost towards targeted yield productivity of integrated crops in contingency, feasibility and brisk

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growth , developmental choice models for thriving and succeeding in agriculture scenario through rolling a successful agricultural Integrated Farming System model and approach, with systems intelligence , thinking and technology at core of heart driving simplicity, spirituality and sustainability of global flat world agricultural productivity, in sync and harmony with mother earth.

Keywords: Systems approach; integrated farming system; regression formula; marquart method; approximated by solver method; fertilizer uptake; optimization models.

1. INTRODUCTION

The All India Coordinated Research Project on Integrated Farming Systems has done on the basis of the report submitted by Dr. A. B. Stewart of Macaulay Institute of Soil [1,2]. Research, Aberdeen UK and established "Simple Fertilizer Trials on Cultivators' Fields" during 1952-53 under the Indo-American Technology Co-operation Agreement and guided to popularization of fertilizer used and substantial increased in crop productivity. "All India Co-ordinated Agronomic Experiments Scheme" was started by ICAR with the "Model Agronomic Experiments" at centers in 1956. Objectives of the model agronomic experiments were to encompass studies on response of HYV of cereals to intensive use of inputs such as fertilizers, irrigation, weed control [1,3] etc. Both schemes were united together in 1968-69 and the "All India Co-ordinated Agronomic Research Project" (AICARP) was approved with the two components. During Seventh Five Year Plan, in 1989, AICARP was elevated to "AICRP on Cropping Systems" to strengthen all aspects of research in cropping systems. The project was renamed as "AICRP on Integrated Farming Systems" during Eleventh Plan period and was effective from April 2009 to undertake remodeled. under farming system mode. The Project Directorate was also renamed as "Project Directorate of Farming Systems Research" (PDFSR) with the following revised mandate [1]. Subsequently, PDFSR got institution status with effect from 27 November 2014 and was renamed ICAR, Indian Institute of Farming Systems research. ICAR, IIFSR is located at Modipuram, Meerut [3].

We have taken that filed and data of multi-crops by taking yield of Integrated crop [1]. To characterize existing farming systems to know the productivity, viability and constraints.

1. Developing resource efficient, economically viable and sustainable integrated farming system modules and models for different farming situations.
2. To found basic and strategic research on production technologies for improving agricultural resource use efficiencies in farming system mode.
3. Developing and standardizing package of production practices [4] for emerging multi cropping/farming concepts and evaluate their long-term sustainability.
4. Acting as repository of information on all aspects of farming systems by creating appropriate data base.
5. To develop on-farm agro-processing and value addition techniques to enhance farm income and quality of finished products.
6. Undertaking on farm trialing, confirmation and clarifying of system-based farm production technologies.
7. To develop capacity building of stakeholders in Integrated Farming Systems.

In Odisha [1], the project was started in 1956 with the cooperation of TCH of USAID and ICAR. In the formative years demonstrations were done to show the benefit of fertilizers to the farming community. Subsequently the objectives of the project went through modifications and it started functioning under the State Department of Agriculture as a research project with the financial assistance from ICAR. After appointment of a Project Co-Ordinator, the project was transferred from the State Government to OUAT in 1968. Presently the programme in Odisha is operating in two On-Stations and two OFR (On-Farm Research) Centers with its headquarters at Bhubaneswar. The Main Centre, located at Bhubaneswar (20° 26' N, 85° 81' E, 34 m above MSL) [5], in addition to its own activities is catering to the needs of coastal Odisha. The sub-centre is located in Sambalpur district with its headquarters at RRTTS, Chiplima (21° 38' N, 83° 90' E, 144 m above MSL) in Hirakud Command to cater the research needs of western Odisha. One of the On-farm Research Centres (OFR) is located in Kalahandi district (since 2017-18) with headquarters at RRTTS, Bhawanipatna (19°40' N, 83° E) and the other OFR center is operating in Kendujhar district since 2017-18 with headquarters at RRTTS, Kendujhar (21° 37' 48'' N, 85° 34' 48'' E).Odisha is located between 17° 52' to 22° 45' N Latitude and 81° 45' to 87° 50' E Longitude and is covered under two Agro Ecological Regions (AER) i.e., No. 12 (hot humid eco-region with red and lateritic soils, J-2C3/4) and No. 18 (hot sub-humid semi-arid eco-region with coastal alluvium, S-7CD2/5) of the country. On the basis of the 15 agro-climatic zones of the Planning Commission, Bhubaneswar, Kendrapara, Jagatsingpur, Cuttack and Jajpur are included under Zone 11 (East Coast Plains and Hills) [3], whereas Chiplima, Kendujhar and Kalahandi are included under Zone 7 (Eastern Plateau and Hills) [1].

The state is divided into 10 agro-climatic zones (NARP Zones). Bhubaneswar, Kendrapara, Jagatsinghpur, Cuttack and Jajpur are located in East and South Eastern Coastal Plains, Chiplima under West Central Table Land Zone, Kendujhar under North central Plateau Zone and Kalahandi comes under Western Undulating Zone. The average rainfall of the state is 1482 mm of which 1320 mm is received during June to September. The average temperature ranges between 23 to 46°C during summer season, 24 to 35°C in wet season and 8 to 24°C in winter season. The state has 8 broad soil [4,2] groups i.e., red, laterite, black, red and black, red and yellow, brown forest, alluvial and saline distributed over 30 districts. The dominant soil [5,4] group is red soil [2] followed by laterite soil. The state has a geographical area of 15.57 million hectare (mha) with the cultivated area of 6.18 mha (39.6%), of which 47% is upland, 28% is medium land and 25% is low land. Paddy is the major crop grown in an area of 40.23 lakh ha, out of which 93% is grown in kharif season and rest 7% in *rabi* season. Out of total *kharif* rice area, 18.5% is in high land, 41.5% in medium land and 40.0% in low land. Limited irrigation (40%) is one of the major problems for intensive cropping. The cropping intensity is 167% and fertilizer consumption is 58.74 kg/ha.

Most of the crops are grown under rainfed conditions and rice is the major crop during kharif season. Low coverage under irrigation in *rabi* season has encouraged non-paddy crops such as oilseeds, pulses and vegetables after kharif paddy. Next to rice (45%), pulses cover 23%, oilseeds and vegetables 8% each of the gross cropped area (88.8 lakh ha) [6]. Considering the problems associated with the crops and cropping systems in different parts of the state, new strategies have been undertaken in addition to the existing ones to concentrate on crop diversification / intensification, nutrient management, organic farming in farming system mode, climate resilient agriculture, conservation agriculture, etc [6,7]. Keeping in view the problems and prospects, the following objectives have been identified to carry out On-Station and On-Farm Research in Odisha during 2013-14.We have taken the data for integrated crop which is cultivated in Bhubaneswar.

2. MATHEMATICAL MODEL AND METHODS

We have built mathematical model with help of some mathematical method as well as mathematical method.

2.1 Model

Different mathematical methods, we have applied with Multiple regression formulas for our non-constraint nonlinear equations to find required fertilizers (Data taken for N, P and K fertilizers) [8-10]. Then we have resolved this by the help of some mathematical methods like Approximated by Solver method and Marquardt Method for optimising data. We have model by taking regression formula and (p-value <= 0.05) of the absolute intercept value and other coefficients of regression equations (1), (2) and (3) and (4).

2.2 Methods

We have taken regression formulas and optimization methods for optimizing our solutions and compared with the previous data. In the paper we have taken [1] data from used traditional method.

2.3 Statistical Analysis for our Model

For our mathematical structurer, we need three response surfaces depicting the effect of different levels of N, P and K fertilisers [11] in trial (Assumed)plantation. They are:-

(i) The yield response surface of Multigrain due to application of N, P and K fertilisers at the beginning of cultivation.
(ii) Response surfaces of plant N, P and K uptake at the intermediate stages of cultivation, expressed as functions of applied N, P and K fertilisers at the beginning of cultivation. Instead of studying effect of N, P and K fertilisers separately on yield, the combined effect of fertilisers

on the yield has been considered because significant correlation between levels of N, P and K and yield has been reported by Singh et al. [8].

The effect of different level of N,P and K on yield of integrated crop is given in Table 1 and Table 2.

The response surface for yield of multigrain, after application of multiple linear regressions [8,10] using data in Table 4, is given by :-Y (N,P,K)

=a+bN+cP+dK+e(N/2)*K+f(N*P)----(1),where(P-value<=0.05)and the value of coefficients a=0.014852,b=0.03459,c=0.04382,d=0.03539 e=0.041677,f=0.010737 for function Y (N,P,K)

We have other regression data are:

MultipleR0.0.660431021,Rsquare=0.59451,Regression=2.06438,Residual=0.024871,Significance F=1.17293.Soequation(1)isY(N,P,K)=36.854+0.012019N+0.0024018P+0.003509K+0.004123(N^2*K)+0.044213(N*P)+0.03509(N*K)+0.444512(K*P)-(2)forY(N).

Similarly Y(N,P,K)=a+bN+cP+dK+e(N^2*P)---(3) for Y(P), wherea=0,00114,b=0.00817, c=0.00782 and d=0.00841,e=0.00973f. for Y(N) only.AgainY(N,P,K)=a+bK+c(N/2*K)+d(N*P)+e(N*K)+f(P*K)+g(N^2*P),wherea=0.00386,b=0.004232,c=0.002231,d=0.003741,e=0.0081124, f=0.007583, g=0.0012019 forY(K).

Table 1. The effect of different level of Phosphorus(P) of Integrated crop

Nitrogen level	Phosphorus level	Pottasium Max level	Phosphorus plant Intake
80	40	40	39.05
80	40	40	28.56
20	40	40	34.56
80	40	40	35.89
60	30	30	33.57
20	40	20	34.07
40	80	80	35.07
60	30	30	30.98
60	30	30	42.88
120	60	120	35.07
80	40	40	39.05
60	30	30	33.57
25	50	50	36.22
20	40	20	34.07
20	40	20	34.07
60	25	50	41.56

Table 2. The effect of different level Potassium (K) of integrated crop

Nitrogen level	Phosphous level	Pottasium level	Max Pottasium Intake
80	40	40	162.01
80	40	40	140.51
20	40	40	144.02
80	40	40	121.66
60	30	30	121.03
20	40	20	113.04
40	80	80	198.47
60	30	30	147.85
60	30	30	147.85
120	60	120	176.97
80	40	40	162.01
60	30	30	147.85
25	50	50	123.77
20	40	20	113.04
20	40	20	113.04
60	25	50	146.05

Table 3. Response Nitrogen (N) for Integrated crop

Nitrogen level	Phosphorus level	Pottasium level	Max nitrogen Intake
80	40	40	179.09
80	40	40	179.09
20	40	40	122.66
80	40	40	179.19
60	30	30	171.07
20	40	20	139.71
40	80	80	178.98
60	30	30	171.07
60	30	30	171.07
120	60	120	198.85
80	40	40	197.09
60	30	30	171.07
25	50	50	141,66
20	40	20	139.71
20	40	20	139.71
60	25	50	173.97

Table 4. Response surface for yield of Integrated crop

Nitrogen intake	Phosphorus Intake	Pottasium Intake	Yield Multi crop
80	40	40	55.08
80	40	40	54.06
20	40	40	49.34
80	40	40	55.87
60	30	30	52.65
20	40	20	48.88
40	80	80	51.65
60	30	30	53.03
60	30	30	54.01
120	60	120	62.24
80	40	40	56.76
60	30	30	55.01
25	50	50	54.82
20	40	20	49.74
20	40	20	49.01
60	25	50	55.01

3. MATHEMATICAL FORMULA AND ALGORITHM

3.1 Mathematical Formula

We have taken in accounts two values f_{max} and fo_{ptimum} for both given fertilizers (Phosphorus, Nitrogen, Potassium). We have assumed that f_{max}(N)=230kg/h and f_{max}(P)=40kg/h and f_{max}(K)=130Kg/h. We have calculated the optimum value of both fertilizers by taking Approximate Solver method and multiple regression formula (1), (2) and (3) and found optimum fertilizers both Nitrogen (128.4432 976), Phosphorus (56.43568) and Potassium (163/7865). We have already fixed the boundary point for fertilizer for integrated crop.

We have taken Regression formula for creating equations for fertilizers (N, P, K). Again, we have already hold Approximate Solver method for non-linear unconstraint equations. These equations are optimized by the help of Marquart's method [10].

3.2 Algorithms

Here we have boundary condition (i) Nitrogen, Phosphorus, Potassium) = (20,40,80)

(iii) Nitrogen, Phosphorus, Potassium) = (60,40,20)
(iv) Nitrogen, Phosphorus, Potassium) = (40,60,120).

Step: -1 Here same environment still going on.

If $f_{mmax} \geq fo_{ptimum}$, then result forbidden and we never require any fertilizer to the plant.

Step: -2 Here some natural calamities (flood, drought etc.) we have taken three intermediate points. If normal condition of the environment is happened.

If $f_{mmax} < f_{optimum}$ and boundary condition, then $|f_{mmax}-f_{Optimum}|$=20% fertilizer.

Step: -3 If some insects attaching or some expected diseases happen.

If $|f_{max}-f_{minmax}| \leq fo_{ptimum}$, then $|f_{mmax}-f_{minmax}|$=40% fertilizer.

Step: -4 If unnatural things happen like war and unexpected diseases will happen.

If $|f_1-f_{minmax}| \leq f_{Optimum,}$ then $f1-f_{minmax}$=60% fertilizer. Maximum amount of fertilizer up taken N=230kg, P=40kg and K=130kg.

4. RESULTS ANALYSIS

In Statistical form: - In our mathematical model, we must have three response surfaces depicting the effect of different levels of N and P and K [1,9,10] fertilisers in trial plantation for integrated crop in three critical states of surroundings. They are (i) The yield response surface of paddy due to application of N, P and K fertilisers [5] at first intermediate of cultivation (ii) Response surfaces of plant N, P and K uptake at second intermediate stage of cultivation, expressed as functions of applied N, P and K fertilisers at the beginning of cultivation [7,12].

5. CONCLUSION

In our Paper we have already shown the yield data of the integrated crop from a single field in different top unwanted situation and surroundings. We have already found the up taken fertilizers taken for giving optimum yield of integrated crops in a single field. In different situation and state of disaster we have used different quantity of fertilizer to find enhanced amount of yield of integrated crops. We have also compared optimum yield data with the previous data with optimum solutions.

We have applied mathematical model with mathematical algorithm with the help of Approximate Solver, fminunc function and Marquardt method. We will also used other methods to find more yield of integrated crop by taking other parameters. We will apply other factors and other mathematical methods and another optimal techniques.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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