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Comparative Study of Mathematical Model Applications on the Amount of N-P-K Fertilizer Absorbed to Meet the Best Yield Data of Paddy (Rice) Cultivation

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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

Soil-based test studying prevailing to so many crops in Vindhyan alluvial plains from 2001 to 2004 has shown result of production on special rice crop (IR-36) by testing leveraging on soil stoichiometric testing and recommended balanced fertilizers and organic matter amelioration by application for the niche area of impact to targeted yield of paddy crop. The results confirm that soil micro-flora and micro-organisms speed up aeration, drainage, and the best crumby structures, resulting in embryonic fertility and support for crop plants' profuse and vigorous growth through the best soil texture under various agro-climatological divisions in particular. Preliminary and secondary

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data are calculated after administration of research questionnaire, structure, queue, flow and research objectives, first hand data fulfilment through field tour and experimental block designs under study in paddy-based ecosystem of control and treatment blocks. Nutrients and fertilizers are required for specific accelerated productivity of paddy crop by using control and treatment with specific fertilisers, which is organized in the old mathematical model of [CF (%)] and [CS (%)] gradient. Data in relation to studies of nutrient percentage recommended model development through incursion into stoichiometric trends, analysis, models, algorithms, principles/procedures and quantisation. Regression formulae support the experimental design blocks. Studies by experimental design of blocks replication and finding of experimentations on different mathematical models led to outcome of best efficient recommended fertilizers dose to enrich/replenish the gap of inadequate fertilizers to the paddy (rice) crop to touch our targeted yield of rice crops. Analytical trends and comparison experimentation sheet led to the effort for how much quantity fertilizers are actually needed for paddy crop growth by applying mathematical quantization and qualitative. Under experimental controls, originality of this innovative findings, this research supports systems approach for simplicity, spirituality and sustainability. We have used different mathematical models and three methods and comparing it with traditional method to show the better result of yield data of paddy crop.

Keywords: Nonlinear optimization with no constraints; approximate solver; Quasi-Newton method; Marquardt's method; multiple regression equations.

1. INTRODUCTION

In India the main crop cultivation is Paddy (Rice). Most of the place it is cultivated in huge amount. It is exported in other countries. Damodaran catchment is the most effective place for paddy cultivation in both monsoon and winter season [1]. As paddy is the watery crop, more water, need So more than 85% lands in heavy rainy season (Monsoon) and more than 67% lands in winter season are cultivated. To get more yield paddy, farmers usually more conscious about soils fertility as well as crops nutrients and farmers achieved more yield crops which can be expected by the help of up taking nutrients and fertilizers [2] as fertilizers are major input and important factor of paddy production. Farmers using Nitrogen, Phosphorus and Potassium in most of the paddy lands fertilizers to fulfil their targeted yield in paddy crops. Further ph factor of soils [3,4] need to take into account for paddy cultivation and yield crops. Here we have used both short time and long-time period fertilizers(N-P-K) are used. Again, farmers faced severe problem in cultivation of paddy crops [1] due to unexpected natural calamities (flood, draught, low quantity of raining as well as heavy rainfall etc) and attacked by insects and other sources i.e., inequal distribution of crop cultivation. To enhance the production of crops cultivation and targeted yield of paddy we have taken different intermediate points (M-I and M-II) for paddy cultivation effectively and giving uptake fertilizers [5,6]. To examine and find some optimum value to calculate targeted yield data for paddy crop cultivation mathematical model has taken and created some mathematical formula to get it. Algorithm is produced for solving it. Getting the targeted yield of paddy crop analysed and compared the data to meet the targeted paddy crop production. After analysing we found good results to achieve the targeted yield. We have taken three methods" Quasi- Newton method, Approximated by solver and Marquardt Method." which shows optimum solutions as well as optimizing the solution which has given the optimum solution. We have taken two medium points (intermediate points M1 for 65% fertilizers up taken in monsoon and 35% fertilizers up taken in winter) for up taking fertilizers (N, P, K) when we assume for monsoon season heavy or more heavy rain fall and multiple times flood, heavy storage of rain water in paddy land is the main source of wasting fertilizers from paddy lands which cause inadequate/not sufficient fertilizer supply to the paddy(rice) plant [7] and it will directly affect the production of paddy crops and fulfil the yield paddy crop. Similarly in winter season some other soil problem like drought may arise and also insects' attack problems too. To irradicate the deficiency of fertilizers we take one intermediate point (M-I) where we have decided how many quantities of N, P and K are going to supply to the plant intaking. Similarly, we have applied M-II point if paddy crop not distributed properly in paddy land, then we have applied 75% fertilizers where heavy paddy grass and 25% where less amount of paddy grass. Suppose we have to take Nitrogen and Phosphorus and Potassium, and divided those

fertilizers in two parts one is 65% and other is 35% in (M-I) mid-point and 75% and 25% in (M-II) mid-point by taking it approximate value. We have needed balanced amounts of N, P, K in field [8] were prescribed based on crop-based estimates of the indigenous supply of N, P, K by modelling the expected yield response as a function of fertilizers [9,1] interaction was done by many workers (Dobermann and White 1998; Witt et al., 1999). Our present investigation is to study the relationship between the added fertilizers (uptake) [10] and yield/harvest of paddy and to develop the optimum solution by applying mathematical optimization methods/techniques for fertilizers up taken for maximum production of paddy in the same given area. Compared and analysed the data in traditional method as well as our proposed model data.

2. MATHEMATICAL FORMULA (METHODOLOGY) AND APPLIED ALGORITHM

2.1. (a). Model: - Various mathematical methods are applied here for solving the yield of paddy crop. We have implemented Multiple regression formulae for nonlinear equations without constraints for getting required fertilizers (N, P and K fertilizers) [7,11]. After that we have resolved this by applying few mathematical methods/techniques (Quasi -Newton method, Approximated solver and Marquardt Method) for optimising data. We have model by taking regression formula and p-value (always ≤ 0.05) of the absolute intercept value and other coefficient of regression equations (1),(2) , (3), (4) and (5).

2.1. (b) Method: - Regression formulae and three methods of optimization for optimizing our solutions have taken in our paper and compared with the data with previous data [1]. Here in this reference paper [1] which is already found by traditional method (CS% and CF%)by taking the formula i.e. Fertilizer dose=[Nutrient requirement (kg/t) of paddy grain]/ [CF (%)]×100×T (t/ha)−[CS (%)]/ [CF (%)]×[Soil test value (kg/ha)], where T is targeted yield (t/ha).We have exhibited it by finding data in Table 4 and Table 5 and analysed which is the best method and which method has given better optimization value. Our data found by optimization methods/techniques and data from traditional methods (CS% and CF%) is given in different tables (Table 1, Table 2, Table 3, Table 4, Table 5).

2.2 Statistical Analysis I:- In our proposed mathematical framework, we get three response surfaces which is depicting the effect of distinct levels of N, P and K fertilisers in paddy plantation. They are the followings: -

(a) In the first stage the yield response surface of paddy due to application of N, P and K fertilizers at the beginning of cultivation of paddy cultivation.

(b) In the second stage Response surfaces of plant N, P and K uptake at the midpoint/ intermediate stage(M-I and M-II) of cultivation, expressed as functions of applied N, P and K fertilisers at the beginning of cultivation. It is further subdivided into two parts. Instead of studying effect of N, P and K fertilizers separately on yield, the combined effect of the fertilizers on the yield has been considered because significant correlation between levels of N P, K and yield has been reported by Singh et al. [11], Ali et al. [2]. The effect of different level of N,P and K on yield of paddy crop is given in Table 1, Table 2 and Table 3. The response for yield, after application of multiple linear regressions [12] using data in Table 1,Table 2 and Table 3, is given by :-Y (N, P,K) =190+bN+cP+dK+e (NP)+f(PK)----(1), where P-value of a=0.003183, b=0.021982, c=0.017022, d=0.040546,e= 0.025506,f=0.017095 for function Y (N, P,K) We have other regression data are: MS=0.698413, Significance F=0.015822.So equation (1) is Y(N,P,K)= 190+0.021982N+ 0.017022P+ 0,040546K+0.025506(NP)+0.017095(PK)---(2)˙. Similarly Y(N, P,K)= 95+bN+cP+ dK+ePK+f P^2K+g3P*4K+h(PK^2)---(3), where P-value a=0. 000938, b=0.227248, c=0.010621 and d=0.028742,e=0 .13578,f=0. 002137,g= 0.00785,h=0. 022307 for Y(P)only. Again So the equation(3) is (N,P,K)= 89+bN+cP+dK+e (NP)+f(NK)+g(N^2K)+h (NP)—(4),where a= 0.0 39598,b=0.043506,c=0. 046 5418, d=0.0 42183, e=0.042183,f=0. 0243518, g= 0.038564, h=0.035752 for Y(N).Again Y(N,P,K)= 82+ bN+cP+dK+eNP+fNK—(5),where P-value is a=0.014844, b=0.046519, c=0.040002, d= 0.020517,e=0.042713,f=0.0260149 for Y(K) only. After solving regression formula by applying two mathematical methods i.e., Quasi Newton method and Approximated method to find the uptake fertilizers (N, P, K) values. Again, by taking all uptake fertilizers (N, P,K) and applying Marquardt method to obtain optimum solution and using it for find yield data in both intermediate points.

Table 1. Phosphorus, nitrogen and potassium level in plant

Phosphorus level in plant	Nitrogen level in plant	Potassium level in plant	Phosphorus Intake for midpoint M1	Phosphorus Intake for Midpoint M-II
80	100	40	93.67	87.23
50	120	50	72.66	68.20
61	104	70	75.79	69.23
73	126	84	87.23	72.50
80	100	40	92.35	85.15
50	120	40	71.65	65.79
57	100	46	71.22	66.73
70	121	59	73.25	68.21
80	100	40	93.25	82.41
40	100	40	68.15	57.21
46	84	40	68.87	56.31
59	106	53	71.23	67.30
80	100	40	93.66	86.30
40	120	50	67.23	56.31
54	100	62	71.79	67.30
66	120	76	76.32	67.54

Table 2. Phosphorus, nitrogen and potassium intake level in plant Midpoint M2

Phosphorus Intake level in plant	Nitrogen level in plant	Potassium level in plant	Potassium Intake for midpoint M1	Potassium for Midpoint M2
80	100	40	66.12	39.44
50	120	50	72.44	43.25
61	104	70	87.09	57.20
73	126	84	93.99	61.07
80	100	40	66.15	39.88
50	120	40	66.37	39.59
57	100	46	71.60	42.73
70	121	59	73.29	47.66
80	100	40	66.53	39.66
40	100	40	67.15	39.87
46	84	40	68.03	36.38
59	106	53	71.09	37.91
80	100	40	63.67	38.54
40	120	50	69.38	43.37
54	100	62	74.69	47.30
66	120	76	88.32	59.84

Table 3. Phosphorus, nitrogen and potassium intake level in plant for midpoinM1 and MidpointM2

Phosphorus level in plant	Nitrogen level in plan	Potassium level in plant	Nitrogen Intake for midpoint M1	Nitrogen Intake for Midpoint M2
80	100	40	101.45	89.45
50	120	50	72.66	68.20
61	104	70	75.79	69.23
73	126	84	87.23	72.50
80	100	40	92.35	85.15
50	120	40	71.65	65.79
57	100	46	71.22	66.73
70	121	59	73.25	68.21
80	100	40	93.25	82.41
40	100	40	68.15	57.21
46	84	40	68.87	56.31
59	106	53	71.23	67.30
80	100	40	93.66	86.30
40	120	50	67.23	56.31
54	100	62	71.79	67.30
66	120	76	76.32	67.54

Table 4. Phosphorus and potassium intake level in plant for midpoinM1

Phosphorus level in plant	Nitrogen level in plant	Potassium level in plant	Yield data for paddy crop in proposed M-I
80	100	40	6.789412
50	120	50	6.287002
61	104	70	6.023465
73	126	84	7.200981
80	100	40	5.715327
50	120	40	6.586014
57	100	46	6.73 5413
70	121	59	6.821676
80	100	40	8.241573
40	100	40	7.216542
46	84	40	6.310652
59	106	53	6.730457
80	100	40	6.685435
40	120	50	5.631651
54	100	62	6.307654
66	120	76	6.754032

Table 5. Phosphorus, nitrogen and potassium yield data for paddy crop

Phosphorus paddy crop in level in plant	Nitrogen level in plant	Potassium level in plant	Yield data for proposed method-II
80	100	40	7.278941
50	120	50	6.930176
61	104	70	6.502346
73	126	84	7.500954
80	100	40	5.871532
50	120	40	6.787422
57	100	46	6.673 513
70	121	59	7.821676
80	100	40	8.541503
40	100	40	6.721654
46	84	40	6.335652
59	106	53	6.732457
80	100	40	8.685415
40	120	50	5.645651
54	100	62	6.830665
66	120	76	6.678034

3. RESULT ANALYSIS BASED ON DATA

We have accepted two values f_{maxx} and fo_{pt} for our given fertilizers (Nitrogen, Phosphorus and Potassium). We have assumed that f_{maxx}(N)=200kg/h and f_{maxx}(P)=150kg/h and f_{maxx}(K)=130kg/h . Then We have computed the optimum value of fertilizers by considering Quasi Newton method, Approximated Solver method and Marquardt method and multiple regression formula (2) and (3) and (4) and obtained optimum fertilizers of Nitrogen (127.0056) and Phosphorus (100.8000000) and Potassium(95.0876).We have examined the regression formulae with two different methods in mathematical model i.e. Approximated by solver and Quasi Newton method and optimized the solutions by Marquardt method. Again, found yield data in M-I and M-II in Table 4 and Table 5. We have also compared our yield data with the previous data [10] and obtained better result to find more yield than previous data of the traditional method [10] of paddy (rice) crop to meet our targeted yield of paddy (rice) crop. We have developed the required algorithm to meet our targeted yield by applying the algorithm.

3.1 Algorithm1 for Midpoint M1

Step:-1 When we have found intermediate point M1 i.e (65% fertilizer), $f_{maxx}<f_{opt}$,then f_{maxx}-f_{opt}=65% fertilizer required.

Step:- 2 If $f_{max}x \geq f_{opt}$,then fertilizer not required.

Step:-3 If second intermediate point M2i.e.(35%),then f_{max}- $f_{optt,}$then f_{maxx}-f_{opti}=35% required fertilizer .

Step 4:- If $f_{maxx}>f_{opt,}$then excess of fertilizer, fertilizer aborted.

3.2 Algorithm2 for Midpoint M2

Step1:-When we have found mid point 2 we must repeat step 3 of Algorithm 1.

Step2:-When indiscriminate crop is harvested and inadequate fertilizer used, then step1 of Algorithm1 i.e. $f_{maxx}<f_{opt}$,then f_{maxx}-f_{opt}=65% fertilizer required.

3.3 Analysis

From Table 1 we have taken uptake Phosphorous fertilizer in both Midpoint- M-I and Midpoint-M-II. Similarly in Table 2, Potassium fertilizer uptake taken in M-I midpoint and M-II midpoint and fertilizer Nitrogen has taken in both M-I and M-II midpoints' data finding optimum nitrogen by applying fsearch techniques for nonlinear optimization equations without constraint with Quasi Newton method Approximated by Solver methods. By taking Levenberg Marquardt method and taking Table 4 and Table 5 we have evaluated targeted yield crop(paddy) amount Kg/h by taking optimum fertilizers (Phosphorus, Potassium, Nitrogen). Again, we have compared between traditional data and our both methods and we have got it that data of traditional method has given less yield in comparison to our proposed methods which has given more targeted yield crop.

4. CONCLUSION

Taking different optimization (Quasi-Newton, Approximated Solver and Levenberg Marquardt's methods) we have found the conclusion that we have got better and more accurate approximation result than other traditional methods to find targeted yield of any crop by intake different level of Nitrogen, Phosphorus and Potassium up taken for paddy crop in different seasons and other crucial/critical states to produce more paddy crop. We have also grasped both methods (Quasi Newton Method and Approximated by Solver). We have also checked by taking three mathematical methods and two intermediate points (M-I and M-II). In first case if crop need more fertilizers if it has inadequate number of fertilizers and in second case if crop needs less fertilizer to fulfil(mee)t its targeted yield (targeted production of paddy crop.). By taking into account of this reference, researchers and scientists' agriculturists will also examine/ research other optimization methods and also taking other conditions to meet their target and able to produce more paddy crop in different condition/situation at different stages as well as distinct states.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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