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OPTIMIZATION OF CROP YIELD BY LINEAR PROGRAMMING APPROACH

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Abstract:

Agriculture and mathematics are very much related to each other. A linear programming technique from Operations Research, which is a branch of mathematics, is used to optimize the crop yield or crop production.This research paper throws light on how to optimize crop yield by the simplex method by using Excel.

Keywords: Agriculture, mathematics, crop yield.

Introduction:

Agriculture plays an imperative role in the Indian economy. A map published by the U.S.Geological survey(USGS), India has the highest percentage of cultivated land. The contribution of the agricultural Industry in our country's GDP is almost 18% to 19%. More than 50% of our population is involved in the occupation of agriculture or related work. Agriculture is an occupation which has been practiced by humans not only from India, but from all over the world since long ago. As time grew, a lot of changes made in agricultural techniques. Earlier, humans and animals used to do all agricultural work, but now it is replaced by machines. Not fully, but up to some extent ,but still a lot of work has to be done to improve the farmer's condition.

Objective:

1.Although government is taking lot of efforts in this field to improve ,but the results are still below expectation.

2.Our main objective is to make a small attempt to optimize the crop yield, crop production and minimize the land allocation for a greater result with the help of linear programming using Simplex method.

Literature review:

R. Bharathi et al [4] says the linear programming method can be used to find the best crop combination, to allocate the farm resources, to grow a variety of crops, to determine the quantity of crops produced, and minimize the input cost. Paddy, maize, and black gram are the decision variables. The results say the production of paddy, and black gram increased whereas the production of maize remained unchanged. Md. Belal Uddin [1] Explored Linear programming by Simplex method and graphical method to enhance the return of the production of crops. Rimil Nidhi Bhuinyan et.al. [9] selected Ranchi district of Jharkhand state for research. The author explores the importance of agriculture in the country's economy and food security, as it directly affects millions and billions of humans. However, the agricultural industry faces many challenges, which include fluctuation in price, lack of resources, and volatile weather. The author explores a profit maximization model that aims to maximize agricultural production. Lingo 20.0 software is used in the research. S. Supriya et.al.[11] The author states linear programming can be applied to agricultural planning in different contexts. 30 farmers were selected by random sampling technique, and data collected for four crops: paddy, cotton, chilli, and maize, considering the constraints like land allocation, labour working days, fertilizers used, pesticides, seed cost, and the hours machine used for. LINGO 17.0 software is used for the study. The result discusses that using linear programming, there is an increase in net return when compared to the farmer's existing plan.

Research Methodology:

Data Collection: For this paper data and the information is collected from Agricultural statistics at a glance -2022(E&S division, DA & FW). The dataset is consisting of historical data. Open solver software in excel is used in the paper.

Preference of linear programming over other optimization techniques:

Linear programming models are simple to frame and solve over other optimization models. The agricultural sector is bounded by many restrictions, such as limitation of land area, weather conditions, availability of labor, and environmental issues; linear programming can solve all these issues at the same time. Planning of crop rotation, allocation of resources, transportation, livestock, and irrigation all can be addressed by linear programming. It is quite effective in maximizing the profit and minimizing the cost.

Linear programming follows a linear relationship between the variables (straight line). Availability of algorithms and solvers: Linear programming can solve large problems. Non-linear programming follows a non-linear relationship between the variables, which is difficult to solve. In non-linear programming one may get multiple local maxima and minima, which make it difficult to get the best outcome. Machine learning is AI based models that need a large number of datasets to train, and it may be difficult to set exclusive or predictable solution. Dynamic programming breaks down the complex problems into small subproblems and helps to solve recursive structures. In dynamic programming the problems with a large number of decision variables face computational complexity.

Study area: Study area for this paper is the area of pan India.

Table:

Table 1 : Major Crops, Area, Production and Yield in India (Normal Estimates Average of 2016-17 to 2020-21) [11]

Group of crops	Crops	Season	Area(Million Hectare)	Production(Million Tones)	Yield(Kg./Hectare)
Cereals	Rice	Kharif	39.54	99.44	2515
		Rabi	4.35	15.01	3448
		Total	43.90	114.45	2607
	Wheat	Rabi	30.28	102.46	3384
	Jowar	Kharif	1.91	1.91	1005
		Rabi	2.98	2.49	833
		Total	4.89	4.40	900
	Bajra	Kharif	7.40	9.49	1283
	Maize	Kharif	7.54	19.47	2582
		Rabi	1.86	8.31	4463
		Total	9.40	27.78	2955
	Total Nutri/Coarse cereals	Kharif	18.39	32.87	1787
		Rabi	5.47	12.52	2290
		Total	23.86	45.39	1902
	Tur	Kharif	4.71	4.09	868
	Gram	Rabi	9.86	10.44	1059
	Total Pulses	Kharif	14.17	8.73	616
		Rabi	14.94	14.69	983
		Total	29.10	23.41	805
	Total Foodgrains	Kharif	72.10	141.03	1956
		Rabi	55.03	144.68	2629
		Total	127.13	285.71	2247
Oilseeds	Groundnut	Total	4.95	8.35	1688
	Rapeseed & Mustard	Rabi	6.26	8.68	1387
	Soybean	Kharif	11.21	12.15	1084
	Sunflower	Total	0.29	0.23	781
	Nine Oilseeds	Total	25.65	31.87	1242
Commercial crops	Sugarcane	Total	4.71	365.47	77609
	Cotton@	Total	12.35	32.07	445
	Jute & Mesta$	Total	0.72	10.17	2540

Source: E & S Division , DA & FW[11]

@:Million bales of 170 kg. Each (Production) $:Million bales of 180 kg. Each (Production) [11]

Formulation of the problem:

Basically, the solution of the linear programming can be decided by ;

a. Object Function: It is used to find maxima or minima (optimization).
b. Constraints: Are the conditions which needs to express relation between variables.
c. Decision Variables: Determines the value of variables and it generally takes non negative values.

1) The first step is to select the decision variables.[13]
2) In the second step, write the objective function using decision variables.[13]
3) In the third step, we will write the constraints that will help to optimize the objective function.[13]
4) At the fourth step, write the non-negative constraints.[13]

The focus of the problem is to optimize the crop yield production by simplex method using Excel. Only the oil seeds i.e. Groundnut, rapeseed & mustard ,soybean ,sunflower and 9 oil seeds grown are considered for the study. Available land area for cultivating the oil seeds is 48.36 million hectares and total production in this area for all oil seeds is 61.28 million tons.

Methodology:

The objective function is:

Maximise $Z = 1688x_1 + 1387x_2 + 1084x_3 + 781x_4 + 1242x_5$

Constraints

Area

$$4.95x_1 + 6.26x_2 + 11.21x_3 + 0.29x_4 + 25.65x_5 \leq 48.36$$

Production

$$8.35x_1 + 8.68x_2 + 12.15x_3 + 0.23x_4 + 31.87x_5 \leq 61.28$$

$$x_1, x_2, x_3, x_4, x_5 \geq 0$$

Where yield is dependent variable, and area and production are independent variable.

Decision Variables:

x_1: *One unit of Groundnut*

x_2: *One unit of Rapeseed and Mustard seed*

x_3: *One unit of Soyabean*

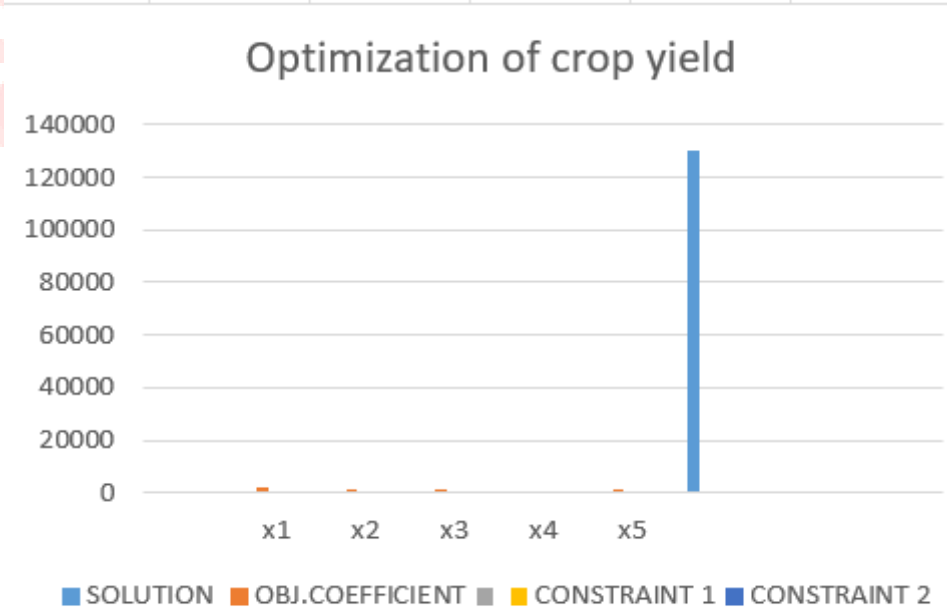
x_4: *One unit of Sunflower*

x_5: *One unit of Nine oil seeds*

Solving this linear programming problem by excel open-solver.

Table 2: Solution of the Simplex method by Excel

	x1	x2	x3	x4	x5	z		
SOLUTION	0	0	0	166.7586	0	130238.5		
OBJECTIVE COEFFICIENT	1688	1387	1084	781	1242			
						LHS		RHS
CONSTRAINT 1	4.95	6.26	11.21	0.29	25.65	48.36	<=	48.36
CONSTRAINT 2	8.35	8.68	12.15	0.23	31.87	38.35448	<=	61.28



Result:

Using Linear programming by Excel in Simplex method optimizes the crop yield of 130238.5 kg/hectare the solution of the problem gives the following results x_1=0,x_2=0,x_3=0,x_4=166.7586 ,x_5=0.It means the production of only the sunflower seeds has increased which is resulting in the optimization of crop yield and there is no change in the production of remaining oil seeds .

Conclusion and Future scope: This paper discusses that operations research can be used very effectively and efficiently in the agricultural sector to decide which crop should be grown in which area to give optimum yield and production of the crop. With the use of big data and precision agriculture, linear programming will have a significant impact on agriculture. As the need for sustainable farming methods increases, the LP has to change to incorporate environmental factors more thoroughly.

References:

1. Md.Belal Uddin et.al. 2023, Application of Linear Programming Techniques in Agriculture, International Journal of Scientific and Research Publications, Vol. 13,Issue 5.

2. Rahul R Yadav 2021, Survey Paper on Prediction of Crop Yield and Suitable Crop, International Journal of Advance Scientific Research and Engineering Trends, Vol. 6, Issue 4,ISSN: 2456-0774.

3. Shikha Ujjainia et.al. 2020, Crop Yield Prediction using Regression Model, International Journal of Innovative Technology and Exploring Engineering, Vol.9, Issue 10, ISSN:2278-3075.

4. R. Bharathi et. al. 2024, A Study On Optimal Crop Allocation Using Linear Programming Approach, Journal of Nonlinear Analysis and Optimization, Vol. 15, Issue 1, No. 6, ISSN:1906-9685.

5. Rodrigue Kongne Nde et.al. 2024, Crop Selection: A Survey on Factors and Techniques, Smart Agricultural Technology (Elsevier), 2772-3755.

6. Falmata Alhaji Zanna , Mathematics for Agricultural Development: A Key for Peaceful Co-Existence, Pristine ISSN:2250-9593.

7. Rahul Banerjee et. al. 2023, An Overview of Statistical Techniques for Analysis of Data in Agricultural Research, Research Gate, Chapter 11, ISBN: 978-81-19761-21-0.

8. Abhishek Purohit et.al.2022, Operation Research in Agriculture, EPRA International Journal of Multidisciplinary Research, Vol. 8, Issue 11, ISSN: 2455-3662.

9. Rimil Nidhi Bhuinyan et. al.2024, A Profit Optimization Model For Agricultural Production, International Journal of Creative Research Thoughts, Vol. 12, Issue 1, ISSN:2320-2882.

10. S. Supriya et.al.2022, Optimal Crop Plan by Using Linear Programming Technique in Jayashankar Bhupalpally District of Telangana: A Case Study, The Pharma Innovation Journal, ISSN:2142-2145.

11. https://www.desagri.gov.in/wp-content/uploads/2023/05/Agricultural-Statistics-at-a-Glance-2022.pdf

12. R. Kunwar et. al. 2022, An Introduction to Linear Programming Problems with SOME Real-Life Applications, EJ-MATH, European Journal of Mathematics and Statistics, ISSN:2736-5484.

13. J. Sandhiya et. al.2023, A Study On Linear Programming Problems In Real Life Applications, International Journal Of Creative Research Thoughts, Vol. 11, Issue 5, ISSN: 2320-2882.