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Mathematics on Agriculture

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Abstract: ***This paper deals with the mathematical approach to agriculture. In this paper some concepts of mathematics that approaches agriculture are being explained. The first part brings out the basics of conversion, number concept, percentage calculations and so on which are being used by the farmers and the agriculturists mainly in India which helps them to understand the nature of crops, land and climate. The next part views the deal of operational research with agriculture. Here the concept of linear programming such as simplex method and assignment method have been used to explain about the easier approach to the decision making in agriculture.***

Keywords: Number system, Linear programming (simplex method, assignment method)

1. Introduction

Mathematics is called "The Queen of Science". It is used in each and every moves of the universe. The uses of mathematics is sometimes noticed and sometimes unnoticed in every walks of life. One of the important field which works on the application of Mathematics is "Agriculture". To be a farmer it is more important to have problem solving, decision making and money management abilities. They use advanced mathematical technology to calibrate machines and irrigation pumps. This paper brings to light some of the important role of mathematics in the agricultural field.

2. Number System

Conversion

A simple concept used in day to day agricultural process is Conversion. A land must be measured in acres. Land is being converted from square feet to acres. This is the foremost simple thing for which the conversion concept is used. 43,560 sq ft is said to be an acre. To plant different kinds of crops in same field for a huge area the land is divided into quarters and sections. A quarter is said to be 160 acres and section is said to be 4 quarters. The prices of the grains will be calculated per tons but producers wants it to be known per bushel. Hence tons will be converted into bushels.

Number concept

Numbers are used to describe and grade seeds. A seed weight is calculated in bushel. EXAMPLE – wheat is said to be 60 ibs/bu, barley is said to be 48 ibs/bu and so on. Seeds are graded with numbers. EXAMPLE – Spring wheat has grade of 1,2,3,4 or feed, durum of grade 1,2,3,4,5 or feed, barley of grade 1,2 or feed, pees are edible at the grade of 2 and so on. To categorize seed number system is used widely.

Percentage measurement

Each and every crop seeds has their own percentage calculation indicating the hardness. HVK which stands for Hardness Vitreous Kernerls indicating the hardness percent of every seeds and grains. This determines the factor of grade by natural translucency. EXAMPLE – a 25 grams of no.1 durum has 80% HVK, no.2 durum has 60% HVK. These are the determinants of the grain and are extremely valuable for the users and consumers.

Linear Programming

The application of linear programming is widely used in many fields. Montazemi and Wright are the first to apply linear programming to agriculture in 1982. It is used to maximize profit of farm by changing the crop structure. Linear programming is the technique for optimizing the linear objective functions subject to linear equality and inequality constraints. It is the powerful technique to find the optimal allocation of resources.

Let us use the simplex method to solve a problem in agriculture..,

Let us consider n decision variables with m constraints. Let Z be the objective function which is to be maximized or minimized. Then,

Maximize $Z = c1x1 + c2x2 + c3x3 + \ldots\ldots\ldots + cnxn$

Subject to

$a11x1 + a12x2 + a13x3 + \ldots\ldots\ldots + a1nxn \leq b1$

$a21x1 + a22x2 + a23x3 + \ldots\ldots\ldots + a2nxn \leq b2$

.

.

$am1x1 + am2x2 + am3x3 + \ldots\ldots\ldots + amnxn \leq bm$

such that $Xj \geq 0$, j=0,1,2,3,…….,n

here,

xj ----> Input variable

ci ----> Cost coefficient of the objective function

*b*i ----> Maximum limit of constraints

aij ----> Coefficients of function constraints equations

Example:

Let us consider a problem. From the table below we shall use simplex method for finding the way of increasing the yield

	OUTPUT/acres	LAND(acres)	CAPITAL/acres
RICE	102	28	60
WHEAT	75	30	52
MAIZE	76	26	46
BARLEY	50	34	30
		118	188

Maximize Z = 102X1 + 75X2 + 76X3 + 50X4

Subject to constraints,

28x1 + 30x2 + 26x3 + 34x4 ≤ 118

60x1 + 52x2 + 46x3 + 30x4 ≤ 188

To equate the constraints we have to introduce the slack variables

Max Z = 102X1 + 75X2 + 76X3 + 50X4 + 0X5 + 0X6

Subject to,
28x1 + 30x2 + 26x3 + 34x4 + x5 = 118
60x1 + 52x2 + 46x3 + 30x4 + x6 = 188

Constructing the constraints in matrix form

$$\begin{pmatrix} 28 & 30 & 26 & 34 & 1 & 0 \\ 60 & 52 & 46 & 30 & 0 & 1 \end{pmatrix} \begin{pmatrix} x1 \\ x2 \\ x3 \\ x4 \\ x5 \\ x6 \end{pmatrix} = \begin{pmatrix} 118 \\ 188 \end{pmatrix}$$

Initial basic feasible solution

$$\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} x5 \\ x6 \end{pmatrix} = \begin{pmatrix} 118 \\ 188 \end{pmatrix}$$

Cj			102	5	76	50	0	0
Cb	Yb	Xb	Y1	Y2	Y3	Y4	Y5	Y6
0	Y5	X5=118	28	30	26	34	1	0
0	Y6	X6=188	60	52	46	30	0	1
Zj=ΣXibi			0	0	0	0	0	0
Zj-Cj			-102	-75	-76	-50	0	0

Y1 enters the basis

$$\text{Min} \begin{bmatrix} 118/28, 188/60 \end{bmatrix}$$

⇨Min (4.2 , 3.1)

Cj			102	75	76	50	0	0
Cb	Yb	Xb	Y1	Y2	Y3	Y4	Y5	Y6
0	Y5	X5=30.36	0	5.92	4.72	20	1	0
102	Y1	X1=3.13	1	0.86	0.76	0.5	0	0
Zj			102	87.76	77.52	51	0	0
Zj-Cj			0	12.76	1.52	1	0	0

Y6 leaves the basis

Old variable-(new variable*cost variable)
118-(3.13*28) = 30.36
28-(1*28) = 0
30-(0.86*28) = 5.92
26-(0.76*28) = 4.72
34-(0.5*28) = 20
1-(0*28) = 1
0-(0*28) = 0
Max Z= 102 X1 + 0 X5
= 102 (3.13)
= 319.26

Hence the maximum yield is estimated through simplex method.

The next method which can also help the decision making in agriculture is the assignment method. Assignment method is one of the easiest and fastest decision making method which involves tasks and resources.

As the name indicates assignment method is used in the areas where there are n tasks and those tasks are to be assigned to m resources in a one to one basis. In those case the cost of the resources are being known and with the impact of assignment problem the tasks which involves lowest cost of resources are assigned with each other.

Let us consider n jobs and n resources

$$\begin{pmatrix} C11 & C12 \ldots\ldots C1n \\ C21 & C22 \ldots\ldots C2n \\ \vdots & \\ \vdots & \\ Cm1 & Cm2 \ldots\ldots Cmn \end{pmatrix}$$

Example

Let us consider that we have to assign project on three varieties of crop harvest to three different persons. The cost of resources they have are given below.

	Rice	Wheat	Corn
Farmer 1	80	40	60
Farmer 2	90	50	20
Farmer 3	80	70	50

SOL: The first step is to subtract the lowest entries of each row with the other entries of respective rows

40	0	20
70	30	0
30	20	0

The next step is to subtract the lowest entries of each column with the other entries of the respective columns

10	0	20
40	30	0
0	20	0

Next let us draw lines through appropriate rows and columns so that all the zero entries of the cost matrix are covered and the minimum number of such lines is used.

	10	(0)	20
	40	30	(0)
	(0)	20	0

Thus from the above table the assignments be like

10	(0)	20
40	30	(0)
(0)	20	0

Thus by the assignment of zeroes in the above table, Rice is assigned to farmer 3,Wheat is assigned to farmer 1 and Corn is assigned to farmer 2.

Let us consider another problem. We have four types of lands and four types of crops. Each crop is to be grown in separate lands. The below table represents the cost of growing each crops in every lands based on the resources available there. To increase the productivity and to reduce the cost of expense let us assign the crops to the respective lands using assignment method.

	Land 1	Land 2	Land 3	Land 4
Crop 1	3000	4000	2000	2000
Crop 2	6000	9000	4000	3000
Crop 3	5000	1000	7000	2000
Crop 4	9000	8000	9000	5000

Solution:
The given table is

3000	4000	2000	2000
6000	9000	4000	3000
5000	1000	7000	2000
9000	8000	9000	5000

Step 1: Subtracting lowest entry from each row

1000	2000	0	0
3000	6000	1000	0
4000	0	6000	1000
4000	3000	4000	0

Step 2: Subtracting lowest entry from each column and drawing lines to cover zeroes.

(0)	2000	0	0
2000	6000	1000	(0)
3000	(0)	6000	1000
3000	3000	4000	0

Here there are four rows and four columns but we have only three zeroes assigned. Thus this is not an optimal solution hence to make it optimal we have to take the lowest entry which is not covered by any lines. Let us subtract that entry with the elements in each uncovered rows and add it to the elements in each covered columns. Therefore we get,

(0)	3000	0	0
1000	6000	(0)	0
2000	(0)	5000	1000
2000	3000	3000	(0)

From the above table the assignment be like

(0)	3000	0	0
1000	6000	(0)	0
2000	(0)	5000	1000
2000	3000	3000	(0)

Here we got the optimal solution. Thus, Crop 1 is assigned to land 1, Crop 2 is assigned to land 3, Crop 3 is assigned to land 2, Crop 4 is assigned to land 4 for the better productivity with low cost.

Agriculture is the most basic necessity for human life. Though we have too many occupations in this world and the technology is being growing advanced the first and foremost need for survival is agriculture. So decision making in agriculture is too important to reduce the chance of loss. Manual decision making and assumption takes much more time and the chance of error may be high. Mathematical approach reduces time also gives a clear view on matters. Thus viewing agriculture in mathematical way enhances better development in the field.

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