Int. J. Agricult. Stat. Sci. Vol. 17, No. 2, pp. 747-753, 2021
DocID: https://connectjournals.com/03899.2021.17.747
www.connectjournals.com/ijass
ISSN : 0973-1903, e-ISSN : 0976-3392
ORIGINAL ARTICLE

OPTIMUM FARMING PLANS FOR MARGINAL FARMERS WITHOUT RESTRICTION ON LIVESTOCK ENTERPRISES USING LINEAR PROGRAMMING MODEL

Jasvinder Pal Singh and Jharna Banerjie*

Department of Statistics, D.A.V. (P.G.) College, Dehradun - 248 001, India.
E-mail: jharna_banerjie@yahoo.co.in

Abstract: Linear programming has been used in agriculture almost since its very inception. Waugh (1951) applied this technique to the problem of minimization of cost of feed for dairy cows. In present paper, a list of marginal farmers belonging to Thano, villages of Raipur block of Dehradun district of Uttarakhand was obtained. An attempt has been made to develop an optimum plan without restriction on livestock enterprises using linear programming model.

***Key words*:** Marginal farmer, Labour employment, Crop rotation, Man days.

Cite this article

Jasvinder Pal Singh and Jharna Banerjie (2021). Optimum Farming Plans for Marginal Farmers Without Restriction on Livestock Enterprises Using Linear Programming Model. *International. Journal of Agricultural and Statistical Sciences.* DocID: https://connectjournals.com/03899.2021.17.747

1. Introduction

Linear Programming has been used in agriculture almost since its very inception. Waugh (1951) applied his technique to the problem of minimization of cost of feed for dairy cows. Complete farm planning by means of Linear Programming was initiated by Heady and Love (1952). Boles (1955) applied Linear Programming in farm management analysis. Waugh (1961) gave solution of practical problems in farm management and micro agricultural economics by linear programming approach. Waugh (1962, 1964) stated about managing farm surplus and demand and price analysis. Barker (1964) conducted a study in the use of Linear Programming in making farm management decisions. George *et al.* (1980) gave their view in American Indian farm planning. John (1987) used mathematical models in farm planning. Sankhayan and Cheema (1991) generated optimum farm plans using linear programming models. Takeshi *et al.* (2003) used their model of crop planning under uncertainty in agricultural management. Hironori (2008) applied linear programming model for agricultural land use planning through the valuation of negative externalities caused by abandoning farmland in marginal areas. Igwe and Onyenweaku (2013) worked on food crops and livestock enterprises planning using linear programming approach. Patel and Chandrika (2017) conducted a study in agricultural land allocation. Padipati and Padi (2017) used optimal programming for crop planning and agricultural resource management. Jain *et al*. (2018) applied optimal techniques for crop planning. Kharisma (2019) conducted a study on vegetable crop rotation planning using linear programming model.

Singh and Banerjie (2020) have given an optimum farming plans with restriction on livestock enterprises using linear programming problem. Dube *et al.* (2020) have done a case study in U.P. for the assessment of the regional disparities in development of agricultural sector. By using different agricultural indicators the development of agriculture of U.P. state are constructed. Prashanti *et al.* (2020) have done field experiment during *kharif* at Hyderabad in strip plot design with four agronomic management options for mitigating the effects of saline irrigation water which were taken as main plots and evaluated with three popular rice varieties of Telangana and one saline

***Author for correspondence** **Received** March 17, 2021 **Revised** July 26, 2021 **Accepted** August 14, 2021

tolerant check variety which were transplanted in sub plots and replicated thrice. Ebreesum *et al.* (2020) have estimated the Quantitative variability of soil structure under the effect of different levels of compaction. The studied soil seems to be very sensitive to compaction, has a weak structure, and less organic matter content, so it needs an efficient management system to avoid the risk of compaction.

2. Sampling Design and Collection of Data

A list of marginal farmers belonging to Thano, village of Raipur Block of Dehradun District of Uttarakhand was obtained and a sample of 50 marginal farmers was selected by using Simple Random Sampling without replacement.

For the collection of data a questionnaire was prepared and was tested through pilot survey (in Kheldi Villages of Haridwar District, Uttarakhand by personal interview method)

For the sake of convenience the schedule was divided into two parts.

In first part information of general nature was collected and in second part detailed information regarding the crop grown was obtained [Singh and Banerjie (2020)].

3. The Linear Programming Model

The objective function of Linear programming model was to maximize total net returns

$$z = \sum_{j=1}^{36} C_j X_j$$

on marginal farms. The net returns (C_j), j = 1, 2,...,19 were calculated for 19 different crop activities (crop rotations). For the livestock activity, namely bullock, the net return was taken as zero (C_{20}= 0). The values of *Cj*, for *j* = 21,…,29, were taken as Rs. 60 each, as it indicates the labour rates per man-day, during the month from July to March. However, during the months April, May and June it was observed that labour rates were slightly higher and therefore the values of C_j, for *j* = 30,…, 32 were taken as Rs. 70 the return from livestock enterprises were also calculated, and were included in the model. The description of decision variable and constraints are calculated by Singh and Banerjie (2020).

4. Development of L.P. Model

On the basis of estimates of various parameters [Singh and Banerjie (2020)] containing 36 decision variables and 27 constraints our objective is to maximize

$$Z = \sum_{j=1}^{19} C_j X_j + \sum_{j=21}^{32} C_j X_j + \sum_{j=33}^{36} C_J X_J$$

Part $= \sum_{j=1}^{19} C_j X_j$ gives the value of net return from crop activities.

Part B $= \sum_{j=21}^{32} C_j X_j$ gives net returns from labour employment and

Part C $= \sum_{j=33}^{36} C_j X_j$ gives net returns from live stock activities.

5. L.P. Plan II and its Optimum Solution

In present paper, L.P. Plans with/without restrictions on livestock enterprises are denoted by L.P.Plan I [Singh and Banerjie (2020)] and L.P.Plan II respectively. As per their existing habits, farmers do not want to keep more than two milch animals. Hence a restriction on maximum number of milch animals was imposed in L.P. Plan I. However, the results of L.P. Plan I indicated that dairying was the most profitable activity for the marginal farmers so it was felt that the relaxation in this constraint may result in a better plan for the farmers and hence the motivation for L.P. Plan II with no restriction on livestock enterprises.

The mathematical formulation of L.P. Plan II remains the same as that of L.P. Plan I except for the two constraints numbered (25) and (26) in Singh and Banerjie (2020) which has been all together removed. The optimum solution of L.P. Plan II using Simplex method was found to be as given in Table 1.

5.1 Interpretation of the optimum solution

For convenience the various activities in L.P. Plan II are categorized as

a. Crop Rotations.

b. Labour Employment outside the family farm.

c. Livestock Enterprises.

The optimum net returns under various activities are presented in the following tables:

Table 1: Optimum values of decision variables.

Decision Variables	Value	Decision Variables	Value
Original X1	.132	X31	2.6126
X6	.087	X32	3.6731
X8	.087	X35	6.7327
X9	.05	Slack X37	6.7327
X17	.0191	Surplus X43	.31
X20	1.00	X44	.16
X21	7.7107	X45	.16
X22	5.2417	X46	.20
X23	6.4217	X47	.02
X26	1.6514	X48	.17
X27	2.7057	X50	335.7
X28	9.7120	X51	559.1
X29	9.6074		
X30	5.9663		

The optimum value of the objective function is Zopt = Rs. 151603.75.

Table 2: Net returns from various crop rotations under L.P. Plan II.

S. No.	Crop Rotation	Area in (ha) allocated	Net return per hec.(in Rs.)	Total net return (in Rs.) %
1	Bajra-Wheat (HYV)	0.132(6%)	24630	325.11 (7.49%)
2	Bajra-Wheat	.0867 (39.4%)	18300	1586.61 (36.58%)
3	Maize-Wheat	.021 (9.5%)	21300	447.3 (10.31%)
4.	Maize+Urd-Wheat	.08 (36.37%)	22050	1764 (40.77%)
5	Bajra + Urd-Unused(Unirrigated)	.0191 (8.63%)	11178	213.5 (4.93%)
			Total	**4336.52**

Table 3: Net return from labour employment (outside) under L.P Plan II.

S.No.	Months	Employment on farm (in man days)	Employment outside (in man days)	Net return per man days (Rs.)	Total net return (Rs.)
1	July	84.2983	7.7017	60	462.10
2	August	86.7583	5.241	60	314.46
3	September	85.5783	6.44	60	386.4
4	October	85.0000	–	60	0.00
5	November	85.0000	–	60	0.00
6	December	83.3486	1.651	60	99.06
7	January	82.2943	2.705	60	162.3
8	February	82.2880	9.712	60	582.7
9	March	80.3926	9.607	60	576.4
10	April	86.0337	5.966	70	417.6
11	May	82.3874	2.612	70	182.8
12	June	81.3269	3.673	70	257.11
			Total		**3441.23**

a) Net returns from crop rotations

The net returns found in the optimum solution are presented in Table 2.

Also,

Unused irrigated area = .31 hectare

Unused unirrigated area = .16 hectare

Total unused land = .47 hectare

Table 2 reveals that only 5 crop rotations are

Table 4: Net returns through various sources under L.P. plan II.

Activities	Net Return (in Rs.)	Contribution to total net Return
Crop Planning	4336.52	2.9
Labour Employment	3441.23	2.3
Milch Animals	143826	94.8%
Total	**151603.75**	**100.00**

Table 5: Net returns from various activities under existing unplanned situation.

Activities	Net Return (in Rs.)	Contribution to total net Return
Crop Planning	10653	19.54
Labour Employment	10670	19.6
Milch Animals	33210	60.86
Total	**54533**	**100.00**

beneficial to the farmers. The maximum area (39.4%) of the total utilized area is occupied by crop rotation "Bajra-wheat". However, the maximum net return (40.77%) to the total net return is contributed by the crop rotation "Maize+Urd-Wheat".

b) Net returns from labour employment outside the family farm

The month-wise human labour employment outside under L.P. Plan II is given in Table 3.

Table 3 indicates that man days available for outside employment are ranging from 1.65 to 9.71. It shows that almost all the family labour is utilized on family farms. The maximum utilization is in the months October and November. It is concluded that utilization of family labour on farm is more in L.P. Plain II as compared to L.P. Plan I.

c) Net returns from livestock activities

The optimum number of milch animals and corresponding net returns in L.P. Plan II is as follows:

Buffalo (Murrah): 6.4234 (*i.e.* 6 or 7) Total net return from milch animals Rs. 143826

Net Returns Under L.P. Plan II at a glance.

On the basis of Table 2 and Table 3 total farm income under L.P. Plan II can be summarized in Table 4.

Table 4 reveals that maximum contribution (94.8%) to the net returns is from keeping of milch animals and the minimum contribution is through labour employment out side. It clearly indicates that dairying is really most profitable activity for marginal farmers as it not only increases the total net returns on family farm but also increase the proper utilization of family members on farms.

5.2 Farm income in the existing unplanned situation

Twenty percent of the sample farmers having highest farm income were selected again in order to know the maximum possible net return under unplanned situation. Average income per year were calculated for these farmers and it was found that average maximum farm income per year was Rs. 54533.

The average net returns from various activities were also calculated for these farmers and are presented in Table 5.

In order to know the income through employment of labour in the existing unplanned situation, the monthly labour employment outside the family farm, were also observed and the average pattern of labour employment is presented in Table 6.

6. Comparative Study

6.1 Comparative study of L.P. plan I and L.P. plan II

Comparing Table 11 [Singh and Banerjie (2020)]of L.P. Plan I and Table 4 of L.P.Plan II, the Fig. 1 shows that L.P. Plan II is better than L.P. Plan I as it provides almost total inside labour which is socially very attractive and increase in net return as compared to L.P. Plan I is higher.

6.2 Comparative study of L.P. plan I and L.P. plan II with existing unplanned situation

(a) Comparison with respect to total income

Comparing Table 11 of L.P. Plan I, Table 4 of L.P.Plan II with Existing Unplanned situation (Table 5), the Fig. 2 shows the net returns of the three activities separately, together with the total net under the existing unplanned situation, along with two suggested plans. The L.P. Plan I is better than the present unplanned situation in every respect as it gives higher net returns increase by crop rotation, increase by labour employment outside and increase by keeping milch animals. The land utilization is also 100%. This is despite of the fact that the labour employment on farm is lesser in this plan.

Table 6: Month-wise labour employment outside under existing unplanned situation.

S.No.	Months	Employment Outside (in man days)	Employment on farm (in man days)	Net return per man day (Rs.)	Total net return (Rs.)
1	July	15	77	60	900
2	August	14	78	60	840
3	September	13	71	60	780
4	October	15	70	60	900
5	November	18	67	60	1080
6	December	11	74	60	660
7	January	10	75	60	600
8	February	9	83	60	540
9	March	11	79	60	660
10	April	20	72	70	1400
11	May	17	68	70	1190
12	June	16	69	70	1120
	Total				**10670**

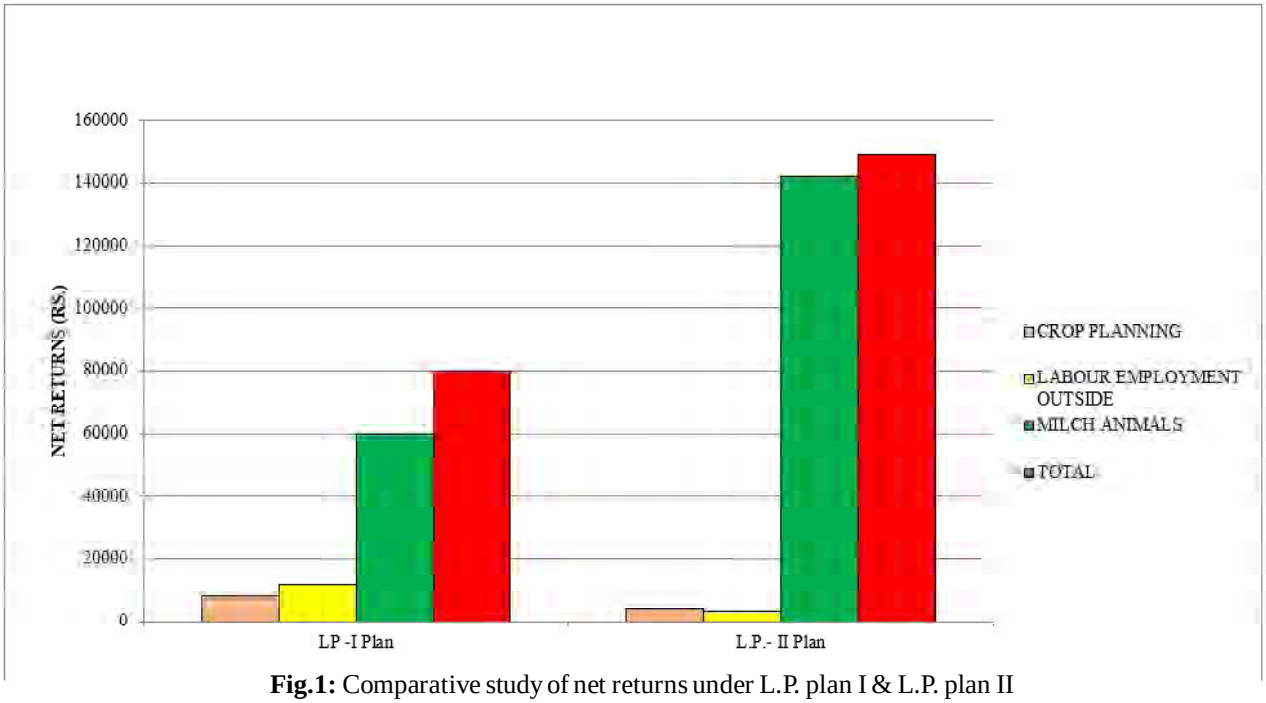

Fig.1: Comparative study of net returns under L.P. plan I & L.P. plan II

L.P. Plan II is even better than L.P. Plan I as it provides almost total inside employment of family labour which is socially very attractive and yields about 175% increase in net returns as compared to existing unplanned situation and about 50.8% increase in net returns as compared to L.P. Plan I. However, for L.P. Plan II additional funds required may be arranged through government sponsored Rural Development Programmes.

(b) Comparison with respect to labour employment on farm

Result of Table 9 **[**Singh and Banerjie (2020)] of L.P. Plan I and Table 3 of L.P. Plan II are presented in the graph of Fig. 3, which represents the pattern of labour employment on farm in different months under existing unplanned situation along with two suggested plans *viz.* L.P. Plan I and L.P. Plan II.

Fig. 3 shows that family labour employment on farm is more in L.P. Plan II than L.P. Plan I. Comparing with Table 6, in existing unplanned situation it is more as compared to L.P. Plan I. Thus in the exiting unplanned situation farmers are using more family

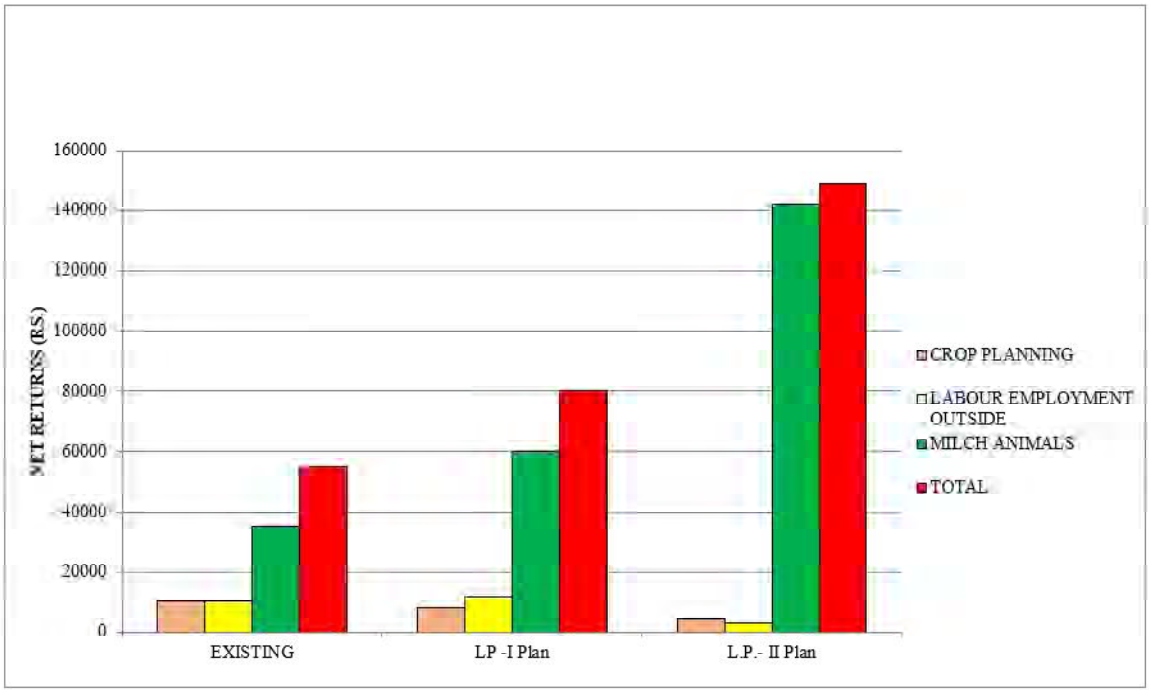

Fig 2: Comparative study of net returns under existing unplanned situation, LP-I, LP-II

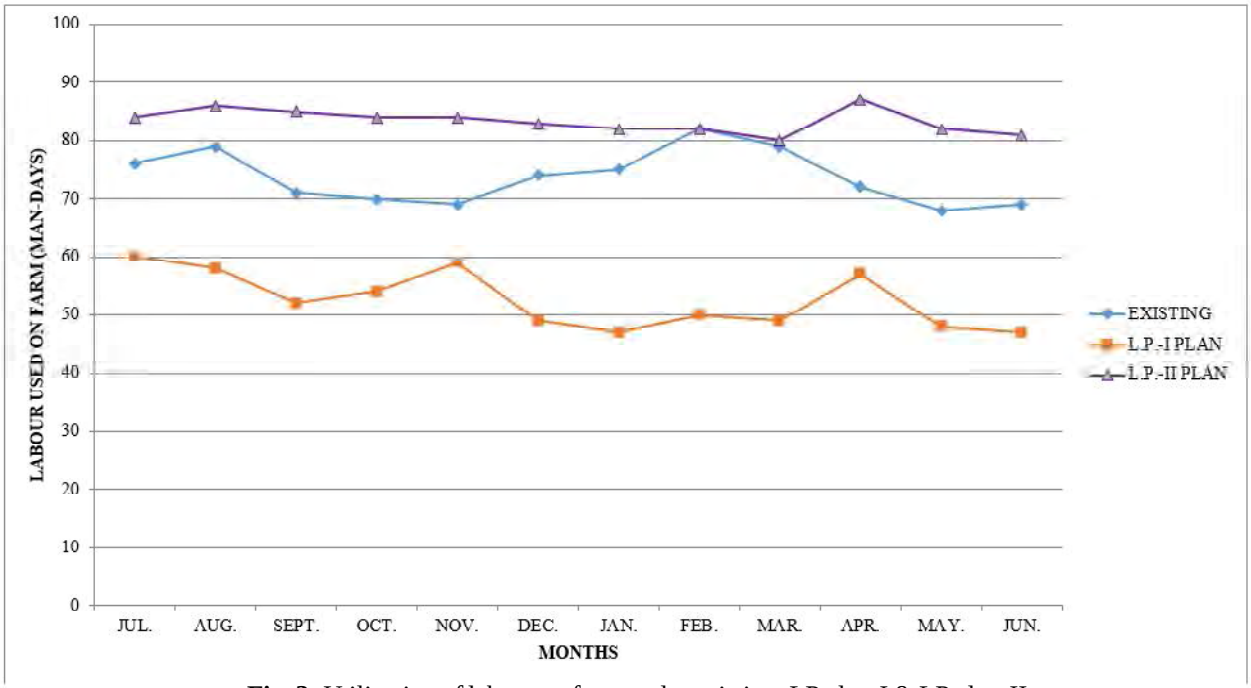

Fig. 3: Utilization of labour on farm under existing, LP plan-I & LP plan-II

labour on farm and still getting lesser net returns both from cropping as well as livestock activities. Surely it is nothing but wastage of a very scare resource. It is, therefore, imperative that the family labour should be employed in some other productive activity either by seeking more employment outside (as in L.P. Plan I) or by doing more profitable family business like dairying (as in L.P. Plan II). Where in, the family labour need not go searching for outside employment and remains engaged in their own family business which is even more profitable than the outside employment both economically as well as socially.

7. Conclusion

Finally we may conclude that in marginal farmers having very small holdings cropping provides the least

contribution to the total income and so the poor farmers must pay greater emphasis on other sources of income may be wage earning through outside employment (as in L.P. Plan I) or adopting dairying is the most profitable activity but it requires additional capital for purchase of animals which may be arranged, if funds can not arranged still with the available resources of land, labour, capital and animals, there is ample scope for improving lot of marginal farmers over the existing unplanned situation by resorting to proper planning as suggested in L.P. Plan I.

References

Barker, R. (1964). Use of linear programming in making farm management decisions. N.Y. (Cornell) *Agric.* Exp. Stat. 993, 42, 100N **48C** U.S. Department of Agriculture, cooperation.

Boles, J.N. (1955). Linear programming and farm management analysis. *Journal of Farm Economics*, **37(1)**, 1-24.

Dube, M, Vishwajeet Singh and S.K. Yadav (2020). Assessment of the regional disparities in development of Agricultural sector. *International Journal of Agricultural and Statistical Sciences,* **16(2)**, 617-624.

Ebreesum, Hamza K. and Ahmed Kareem Abbas (2020). Estimating the Quantitative variability of soil structure under the effect of compaction. *International Journal of Agricultural and Statistical Sciences,* **16(2)**, 687-693.

George, W. Norton, K. William Easter and Terry L. Roe (1980). American Indian farm planning: An Analytical Approach to Tribal Decision Making. *American Journal of Agricultural Economics,* **62(4)**, 689-699.

Heady and Love (1952). Chapter 28: Application of Operations Research Techniques to Farm Management. *Agricultural Economics,* 255-300

Hironori, Yagi (2008). An Empirical Application of the linear programming model for agricultural land use planning through the valuation of negative externalities caused by abandoning farm land in marginal areas. *The Japanese Journal of Rural Economics,* **10**, 1-11. https://doi.org/10.18480/jjre.10.1

Igwe, K.C. and C.E. Onyenweaku (2013). Linear Programming Approach to Food Crops and Livestock Enterprises Planning in Aba Agricultural Zone of Abia State, Nigeria. *American Journal of Experimental Agriculture*, **3(2)**, 412-431.

Jain, Rajni, L. Malangmeih, S.S. Raju and Shivendra Kumar Shrivastava (2018). Optimization techniques for crop planning-A Review. *Indian Journal of Agricultural Sciences*, **88(12)**, 1826-1861.

John, J.G. (1987). Mathematical models in farm planning- A survey operations research. *Operations Research,* **35(5)**, 641-666.

Kharisma, A.P.T. (2019). Linear programming model for vegetable crop rotation planning: A case study. *International Journal of Agricultural Resources*, Governance and Ecology, **15(4)**, 358-371.

Paidipati, K.K. and T.R. Padi (2017). Optimal programming problems for crop planning and agricultural resource management. *Archives of Business Research,* **5(12)**, 282-293.

Patel, N. and Thaker M.C. Chandrika (2017). Agricultural land allocation to the major crops through linear programming model. *International Journal of Science and Research*, **l6(4)**, 519-522

Proshanti, B.K. Suresh V. Ramulu and S. Sridevi (2020). Growth and Yield attributes of various rice varieties under saline irrigation water as affected by agronomic management practices. *International Journal of Mathematical Sciences,***16(2)**, 599-606

Sankhayan, P.L. and H.S. Cheema (1991). Using linear programming models for generating optimum farm plans. *Indian Journal of Agricultural Economics Bombay*, **46(4)**, 601-612.

Singh, J.P. and Jharna Banerjie (2020). Optimum farming Plans for marginal farmers with restriction on livestock enterprises using linear programming. *International Journal of Mathematical Sciences,***16(2)**, 719-731.

Takeshi, I., I. Hiroaki and N. Teruaki (2003). A model of crop planning under uncertainty in agricultural management. *International Journal Production Economics,* **81-82**, 555-558.

Waugh, F.V. (1951). The minimum cost dairy feed-An application of linear programming. *American Journal of Agricultural Economics,* **33(3)**, 299-310.

Waugh, F.V. (1961). Linear programming approach to the solution of practical problems in farm management and micro-agricultural economics. *Journal of Farm Economics,* **43(2)**, 404-405.

Waugh, F.V. (1962). Managing farm surplus. A statement by the NPA agriculture committee, Washington D.C., *National Planning Association Planning, pamphlet*, **117(6)**, 90.

Waugh, F.V. (1964). Demand and Price Analysis. Economic and Statistical Analysis Division, U.S. Department of Agriculture, *Technical Bulletin,* 1316.