A Development Web Application for Planning Cultivated Vegetable to Maximize Profits in Nam Kam District, That Phanom, Nakhon Phanom Province, Thailand*

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Abstract

In this paper the mathematical model is proposed to optimize the vegetable cropping pattern in Nam Kam District, That Phanom, Nakhon Phanom Province, Thailand. The results showed the potential of the model to optimize vegetable cropping pattern and estimated profit about 10,327.36 $US. (327,219 THB) with celery and coriander. A web application for vegetable crop selection and planning has also been developed for easy access enabling the farmers to utilize via mobile phone. A web application offers the cropping pattern similar computing mathematical model technique.

Keywords: Vegetable farm, production planning, Nakhon Phanom Province.

Introduction

Agriculture is an important sector in the economy and represents a valuable source of income and employment (Filippi et al, 2012). Vegetable growing is an important sector of agriculture providing fresh vegetables throughout the year. It is important for survival of any business including vegetable growing, to have food security. For survival of any business, including vegetable plant, it is important to maximize profits (Szewzyx and Kaliczyriska , 2017). In Thailand agriculture contributes significantly to the Thai economy. The demand for vegetables has increased sharply in many parts of Asia including Thailand. Data on the production of main crops in Thailand show that there is an increased production of vegetables with a corresponding increase in planted areas (Chalermpol et al, 2014).

Many vegetable farmers used crop rotation techniques to make their cropping plans. The decisions for crop rotations have a critical impact on crop yields over the long term (You and Hsieh, 2017). It is a common problem in the optimization and allocation of production

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*The 6th Greater Mekong Sub region International Conference (GMSIC) 2019 resources (Stamenkovaska et al, 2012). A simple criterion is often used in practice for crop selection in Thailand included past knowledge and experience, which results in large variations in productivity. Kumari and co-worker (2014) have said that using instinct and experience cannot guarantee maximum profits. The right crop selection for a specific field can maximize the crop yield and numerical simulation was a useful method to developing crop decision. Farm production planning is a complex process. A vegetable's harvestable periods may consist of several days or several weeks. Generally, the harvest schedule for proper vegetables' collection times and size is based on market demands. Since demands usually change evenly over time, farmers will harvest their corps several times to match supply with demands (You and Hsieh, 2017). Agricultural economics, which deals with scientific planning for agricultural development, has become an important area of specialization in agriculture.

Crop optimization has received extensive attention in recent years. It is a widely used approach to solve problems of production planning based on optimal resource allocation given the changing conditions that farms face. Mathematical models have been developed to determine the optimal use of the available resources for maximizing the net benefits subjected to some constraints. Various modelling techniques have been developed by concentrating on the most efficient use for the available resources. This method includes linear and nonlinear optimization models (Alabdulkader et al, 2012; Osama et al, 2017; Stamenkovaska et al, 2012).

Linear Programming (LP) is utilized by all sorts of firms in making decisions about establishment of new industries and in deciding upon different methods of production, distribution, marketing and policy decision making. LP model is perhaps the most important and best-studied optimization problem. LP technique is appropriate in optimization of resource allocation and achieving efficiency in production planning particularly in achieving increased agriculture production. Many real-world problems can be formulated as linear programming problems (Haouari and Azaiez, 2001; Sofi et al, 2015).

In this perspective, the aim of the paper is to develop and present an optimization model to support the decision-making by the vegetable farming group in Nam Kam district, That Phanom, Nakhon Phanom, Northeastern Thailand. A mathematical model has been formulated to achieve the ultimate objective of this study using the LP Model. This is reliable software used for solving optimization models (Alabdulkader et al, 2012). A web application for vegetable cultivation and planning has also been developed for easy access, which enables the farmers to utilize a valuable tool for future vegetable production.

Research Methodology

Problem description

Problem: the farmer's objective is to look for the optimal selection of vegetable crop. The model was formulated to find the optimal cropping pattern, which gives the maximum profitability according to the available area.

Basic notation and expected profit maximization model

Optimization is a commonly used approach to solve the problem of production planning. Linear programing (LP) is the most often used mathematical programing method, because of its simplified linear and normative nature (Stamenkovska et al, 2012). The model was set in MS Excel, using Excel Solver for calculation of optimal solution.

Let:
i be the vegetable type (i = 1, 2,…, m),
s be the planting date or cropping time (s = 1, 2, 3,…, n),
t be cropping season or planting period (the period from planting to harvesting date) of vegetable i,
AC_i be the land preparation cost vegetable i,
SC_i be vegetable seed cost of vegetable i,
CC_i be the plant maintenance cost of vegetable i ,
HC_i be vegetable harvest cost of i,
P_{it} be price of vegetable i in the planting period t ,
Y_{it} be yield of vegetable i in the planting period t ,
L be the cultivation area for vegetable crop i as the land of farm limited. $L \leq 1$ Rai,
F be the size of cultivate vegetable bed and
Q_{it} be amount of vegetable bed of vegetable i in planting period t.

The goal is to allocate the amount which maximizes a high level of profit (Maximize profit: Max Z).

The model for crop selection as follows:

Objective function

$$Max\ Z = M\sum_{i=1}^{M}\sum_{s=1}^{N}\sum_{t=1}^{O} P_{it}Q_{i(t+L_t-1)}Y_{it} - \sum_{i=1}^{M}\sum_{s=1}^{N}\sum_{t=1}^{O} AC_iQ_{it} - \sum_{i=1}^{M}\sum_{s=1}^{N}\sum_{t=1}^{O} SC_iQ_{it} - \sum_{i=1}^{M}\sum_{s=1}^{N}\sum_{t=1}^{O} CC_iQ_{it} - \sum_{i=1}^{M}\sum_{s=1}^{N}\sum_{t=1}^{O} HC_iQ_{it} \quad (1)$$

The objective function (1) maximizes the sum of net profits of all the selected crops. The net profit for each crop is measured as the difference between the expected revenue and the sum of cost related to the operations required to cultivate the crop. Value of revenue depends on the unit price (P) and yield per bed (Y) and amount of vegetable bed of vegetable i in planting period t (obtained by multiplying P_{it} by Y_{it} and Q_{it}).

Constraints

The optimization method must be fulfilling some constraints. In this method, we use vegetable bed constraint. The total vegetable bed must be less than or equal to the total available vegetable bed. So vegetable bed can be declared as in equation (2). In the non-negative constraint, the decision variable must be greater than or equal to zero, as shown in equation (3).

$$\sum_{i=1}^{M} \sum_{t^*=t-L_i}^{t} Q_{it^*} \leq F \quad ; \forall_t \tag{2}$$

$$Q_{it} \geq 0 \quad ; \forall_{it} \tag{3}$$

A Real Case Study

The stated model is applied to the real case of 30 vegetable farmers in Nam Kam district, That Phanom, Nakhon Phanom, Thailand.

To achieve the objective function, a methodological approach in three phases was employed. In the first phase, the study production processes, cost of production, yield market price response factors were obtained from literature (Nam kam District of Agricaltural Extension Office, a five-year period commencing 2014 to 2018). Primary data was collected by interviewing the farmers during January and March 2018 (see Figs. 1 and 2, and Table 1 and Table 2).

Table 1. Type of vegetable and planting period in Nam Kam district, That Phanom, Nakhon Phanom, Thailand

Type	Spring onion	Chinese kale	Morning glory	Chinese cabbage	Cabbage	Lettuce (salad)	Coriander	Tomato	Dill
Planting period (week)	6	7	3	5	6	6	6	12	7

Table 2. Cost of vegetable production of farmers in Nam Kam district, That Phanom, Nakhon Phanom, Thailand

Vegetable	Total variable cost ($US / 1 Rai)	Total fixed cost ($US / 1 Rai)	Total cost ($US / 1 Rai)
Spring onion	817.91	58.44	876.35
Chinese kale	730.16	58.44	788.6
Morning glory	586.58	58.44	645.02
Chinese cabbage	731.65	58.44	790.09
Cabbage	600.64	58.44	659.08
Lettuce (salad)	705.3	58.44	763.74
Coriander	721.01	58.44	779.45
Tomato	727.56	58.44	786
Celery	700.14	58.44	758.58
Dill	997.11	58.44	1055.55

Note: 1 Rai = 0.6 hectare, 1 $US = 31.66 THB

The most frequent types of vegetables are spring onion, Chinese kale, morning glory, Chinese cabbage, cabbage, lettuce (salad), coriander, tomato, celery, and dill. Fig. 1 provides the yield response factor for the different growing states of each of the crops in $US per Kilogram (Kg).

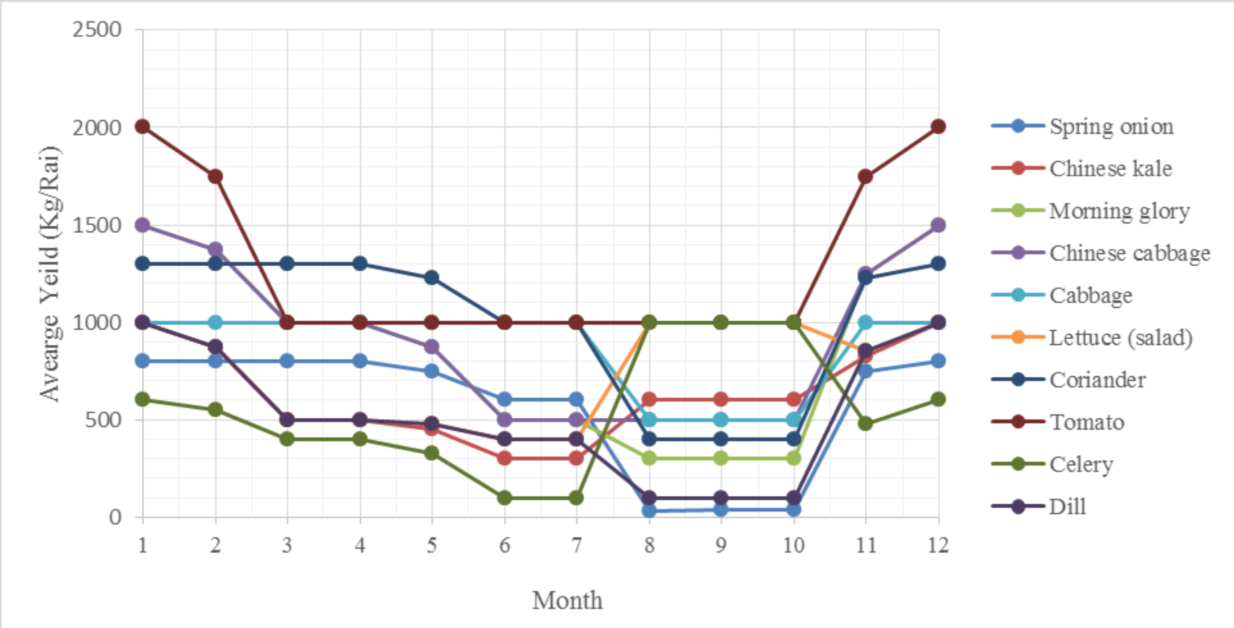


Fig. 1. Average yield of 10 vegetables during 12 months

Fig. 2 shows the market price for the different crops. Table 1 contains the planting period (planting date to the harvesting date) unit in the week. Table 2 provides the cost of production for each of the crops.

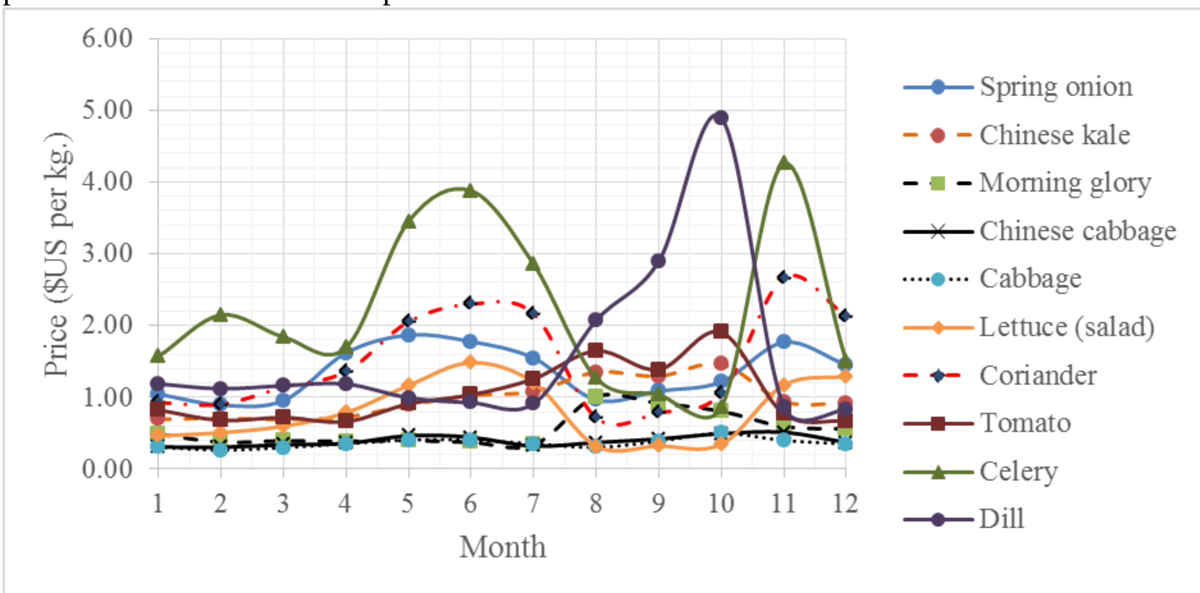


Fig. 2. Average price of 10 vegetables during 12 months.

Moreover, to determine the factor affecting to farmer decision making was conducted by use of the questionnaire. From this study, profit, market demand and production costs were the main factor affecting to farmer's decision to grow vegetables.

In the second phase, the mathematical sector model was formulated to achieve the ultimate objective of this study using the Solver function on Microsoft Excel.

Finally, in the last phase, there was a web application for vegetable plan. Cultivation planning has been developed for easy access by System Development Life Cycle. Validation of the developed web application comparing profits, planting and harvesting plans was derived from mathematical figure using the Solver function on Microsoft Excel.

Research Results

In this paper, 520 variables were computed for optimizing vegetable crop planning by Solver the objective function on Microsoft Excel. An average yield of each crop is divided by 12 months. The growing results and cost of ten different types of vegetables over an annual (52 weeks) were determined at a cost of 1 Rai (0.6 hectare). The optimal selection of crops and operations timing are done to guarantee the best expected profit (revenue minus costs). The result shows that optimal production was achieved from two crops, celery and coriander crops (see Fig. 3).

From Table 3, the cultivate plan of celery and coriander crop based on the mathematic model is as follows: to grow coriander in the first week and harvest in week 8, to grow celery in weeks 9, 20, 31 and 42 and harvest in weeks 19, 30, 41 and 52, respectively.

Table 3. Computational results for plantation schedule under optimization method.

Vegetable	Week		Size of cultivate (Rai)
	Planting	Harvesting	
coriander	0	8	1
celery	9	19	1
	20	30	1
	31	41	1
	42	52	1

The profit between one crop and mixed crops. In this paper, we compared the profit between one crop plantation and vegetable plan using this mathematic model (Coriander and Celery). Table 4 shows the results, when we increase the number of crop the total profit are also increased. The profit from crops using the mathematic model is greater than one crop production. Based on this mathematical model, a total farm profit of 10,327.36 $US.

Table 4. Computational results of profit comparison between one crop production and profit crop based on mathematical model

No	One crop production	Profit per year ($US)	Profit from crop based on mathematic model ($US)	Difference ($US)	Different percent (%)
1	spring onion	4,768.39	10,337.04	5,568.95	117
2	Chinese kale	1,503.53		8,833.80	588
3	morning glory	3,433.84		6,903.50	201
4	Chinese cabbage	1,227.96		9,109.38	742
5	cabbage	1,218.01		9,119.33	749
6	lettuce (salad)	2,026.29		7,301.05	240
7	coriander	9,207.41		1,129.93	12
8	tomato	2,840.64		7,496.69	264
9	celery	5,712.12		4,625.22	81
10	dill	577.97		9,759.37	1689
Average		**3,352.62**	**10,337.04**	**6,984.72**	**208**

Note: 1 $US = 31.66 THB, crop based on mathematical model are coriander and celery (time period of plantation see Table 3)

A web application for crop planning. A web application for vegetable cultivation planning has been developed for easy access to farmers. Fig. 3 shows the results of cultivation planning by application developed by System Development Life Cycle.

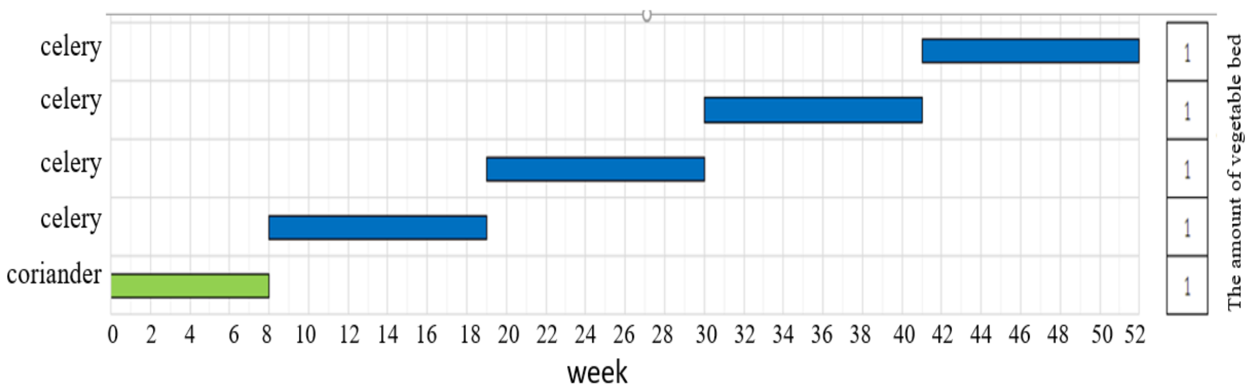


Fig. 3. An application results for optimal vegetable crop and planting periods under optimization method

Table 5 showed the comparison of performance between a web application and a mathematical model was conducted to help solve crop planting.

The seven problems solving are follows:

1) Spring onion, Chinese kale and morning glory, planting period during January to December.
2) Chinese cabbage, cabbage, lettuce, planting period from January to December.
3) Spring onion, Chinese kale and morning glory, planting period during January to December.
4) Tomato, celery, dill , planting period from January to December
5) All of ten crop, planting periods from January to April.
6) All of ten crop, planting periods from May to August.
7) All of ten crop, planting periods from September to December.

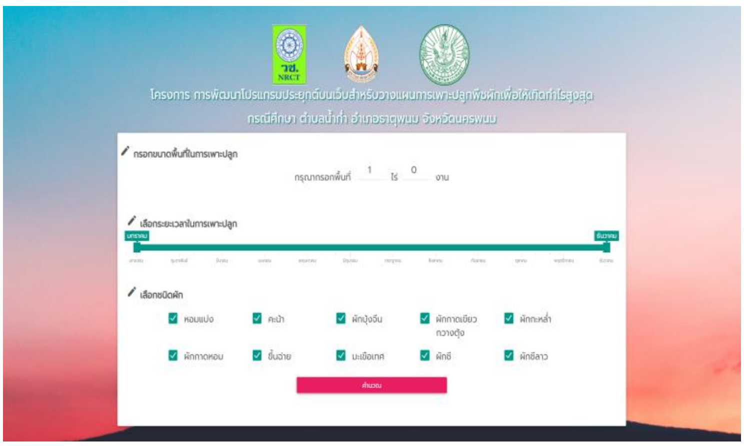
The results show that the application performance did not differ from the mathematical model solving (see Table 5, mistake = 0)

Table 5. Comparison between mathematical model and an application problem solving on web site

The problem solve	Calculation results (profit)		Mistake
	Mathematical model	An application on web site	
1	177,707	177,707	0
2	96,890	96,890	0
3	327,219	327,219	0
4	195,037	195,037	0
5	69,628	69,628	0
6	65,742	65,742	0
7	136,454	136,454	0

Note: 1 $US = 31.66 THB

The application on web site show in Fig. 4 (in Thai language).



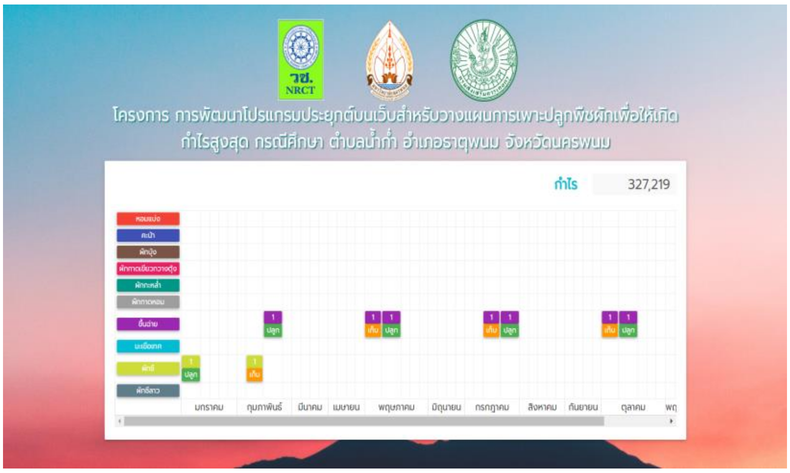


Fig. 4. The example of a web application for vegetable planning (in Thai language), http://ie-advisor.com/vplaning.

Conclusion

To conclude, the aim of this study was to devise mathematical model to optimize vegetable crop by using login 16 program, and to create an application for optimizing a cropping pattern. The small examples based on the historical data base is on real case study. The modelling is aimed only to maximize the total profit. An application on web site in the present work could support the farmer's decision making on vegetable planning. The program will continue to be monitored and adjustments will be made to ensure successful vegetable cropping in the future.

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