Chemical Fertilizer Inventory Management with Forecast Method: Case Study Chaifah Kasetsart Company Limited

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ABSTRACT

In this research, warehouse management was carried out using the forecasting method of Chai Fah Kasetphan Company Limited. From site survey, they found a problem in the management of 9 chemical fertilizer brands, which has a sales value of more than 300 million baht per year. Therefore, historical sales data from January 2019 to December 2019 are used for 4 forecasting formulas and 2 formulas for improving the percentage weighted forecast value to compare the complete discrepancy value (MAD) with the actual sales results in January 2020 and a weighted percentage forecast improvement applied in February 2020. The results of the research revealed that the total gap of the actual sales forecast for January 2020 was -23,361 sacks. This indicates that, there are not enough chemical fertilizers for sale and no chemical fertilizer inventory. Therefore, the research has improved the forecast value by designing a weighted percentage to get a comparison gap (Gap) totaling 17,121 sacks. The results of this research can be used as good information for managing the company's inventory, Chaifah Kasetsart Co., Ltd.

INTRODUCTION

Present business operations, there is an intense business competition and every business must act to accommodate the changes in order to enter the competition. Businesses therefore find management techniques for businesses that can create strengths and increase competitive potential to be superior to competitors and increase their competitiveness to outperform their competitors, but also taking into account the profit and customer satisfaction is of utmost importance. The forecasting technique is one method that brings mathematics and statistics which

applied for planning and decision-making in both short-term and long-term operations. In addition, forecasting is also a tool to help obtain production or inventory management information including future sales. Moreover, forecasting is a very important role in the organization for use in management. Therefore, forecasting plays a very important role in the organization for use in management. How to use each forecast effectively is determined by the error occurred with the smallest difference from the forecast which selecting the appropriate forecasting formula, several factors should be considered. (Rerkkasem, 2018)

Chai Fah Agricultural Products Co., Ltd. is a company that operates in the distribution of agricultural products and chemicals such as chemical fertilizers and various agricultural equipment's for over 18 years. Mr. Niphon Lek-uthai and Mrs. Napawan Lek-uthai are the owners of the business. They established a business to sell products to customers who are farmers; most of the population in Uttaradit is agricultural occupations. (Statistics of Uttaradit Province, 2021) Therefore, agricultural products, tools and agricultural equipment are used as well as chemical fertilizers in large quantities. As a result, the annual sales volume is worth more than 700 million baht, which is divided into agricultural products about 300 million baht, agricultural tools and equipment 100 million baht, and chemical fertilizers 300 million baht. It can be seen from the high value sale of chemical fertilizers each year. Therefore, the quantity of chemical fertilizers is important for forecasting both procurement and storage. In order not to have problems with inventory that is too large or too small. Therefore, the research groups are interested in studying and analyze the problem and apply the forecasting technique to solve for chemical fertilizer products of Chaifah Kasetphan Co., Ltd. The objective of this research is to study the appropriate forecasting methods for planning and controlling chemical fertilizers and to compare the actual sales of chemical fertilizers with the forecast of the Company's chemical fertilizer demand.

THEORIES AND RELATED RESEARCHES

The research group reviewed the literature on concepts, theories and related research. The study of data from various sources is shown as follows:

1.Theories related involved in the study of classification of forecasting techniques are divided into 2 major techniques (Tian et al, 2021; Gryna, 2007; Kaiyawan, 2010) including Qualitative Forecasting Techniques and Quantitative Forecasting Techniques as shown in Figure 1. (Aemo, 2020; Puk-in, 2019; Huang et al, 2021; Sharma, & Machiwal, 2021)
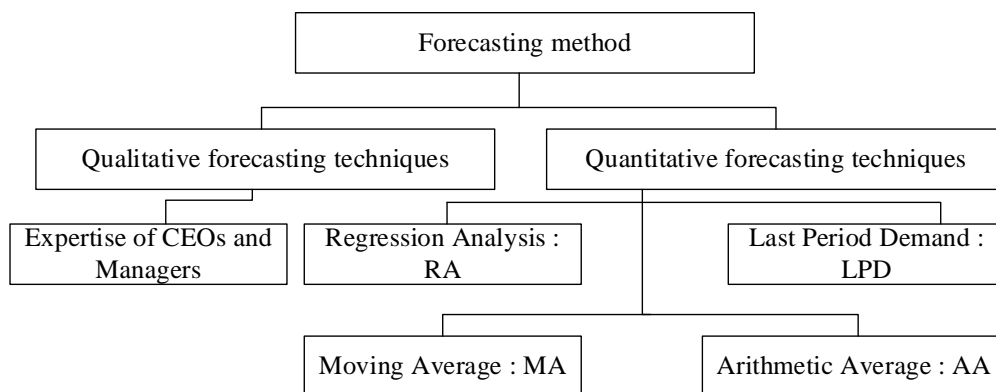
Figure 1: Classification of forecasting techniques (Tian et al, 2021; Hu, 2019))

1.1 Qualitative Forecasting is a forecast based on the opinions of people related to the product, experience, (Tian et al, 2021; Dahooie et al, 2021) knowledge and ability or the judgment of the prophecy. The Delphi Method is a method that relies on the thought of an expert to see the future based on their experience, knowledge, and ability. The Jury of Executive Opinion is a method of asking the opinions of those involved but in the management position. (Joseph & Aiello, 2008) How to ask from buyers (User's expectation) and how to ask from sales (Field sales force) use the marketing knowledge of sales staff. (Hu, 2019)

1.2 Quantitative Forecasting will use mathematical techniques, (Tian et al, 2021; Joseph & Aiello, 2008) based on historical data collected. Quantitative forecasting is a historical data-based technique. Formula or method established by mathematical or statistical principles. (Guo et al, 2021; Li et al, 2021; Piasakul, 2006)

2. Researches related to the review of chemical fertilizer inventory management literature using forecasting methods are presented below.

Hossain, G. et el, (2020) This research has installed intelligent sensor systems on weaving machines. In order to have a system of electronic sensors in a retail store shelf, to record inventory management together with forecasts for use as production data. Research is an in-store shelf application for inventory management records for retailers. As a result of this research, sensor systems connected to weaving machines were able to connect data embedded in retail store shelves; enabling inventory-related data to be monitored against production can be predicted.

Cao,Y. & MaxShen, J., (2019) This research has applied quantitative forecasting and commodity management methods with Data-Driven Inventory under uncertain demand. This research presents a procedural framework for time-series number forecasting together with the proposed techniques that can be used as a data-driven approach to determine the level of inventory in the environment of information issues and the extension of several periods of empirical theory. The method was found to be effective in modeling and time series with unstable forecast data.

Li, J. et al, (2021) This research consider how to allocate inventory of seasonal goods in a two-echelon distribution network for Dillard's Inc., a large department store chain in the United States. Our objective is to allocate products with limited

inventory from a distribution center to multiple retail stores over the selling season to maximize total sales revenue. Under the assumption that the true demand distributions are available to the retailer, we develop an effective dynamic inventory allocation heuristic.

MATERIALS AND METHODS

The research was planned to manage the chemical fertilizer inventory by using the chemical fertilizer demand forecasting method of Chaifah Kasetphan Co., Ltd., there are steps to follow. (Tian et al, 2021; Gryna, 2007; Nawanpee et al. 2019)

1. A study of information is on inventory management of Chaifah Kasetphan Co., Ltd. The company has a Business Trading Characteristics consist of Agricultural products, Agricultural tools and equipment and Chemical fertilizers are stored in the warehouse, as shown in Figure 2.
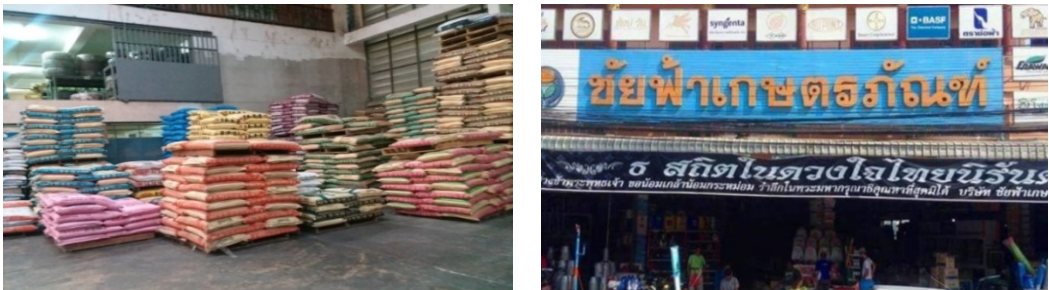

Figure 2: the warehouse of Chai Fah Kasetphan Co., Ltd.

From Figure 2: Businesses use computerized software to manage their inventory by controlling the disbursement of goods in warehouses with large areas. The research group selected 9 brands of chemical fertilizer inventory forecasts for use in planning and order management preparation of funds, labor preparation and storage space which the company has not planned in this manner before. Most of the management uses the experience of experienced management and staff.

2. Processing and Data Collection: The research used the data of chemical fertilizer sales, retrospectively from January 2019 to December 2019 for a total period of 12 months to be used as data in forecasting with various formulas and the forecast results to measure the performance of the forecast with the value of Mean Absolute Deviation: MAD, compared to the actual value in January 2020 and February 2020.

3. Statistical data analysis method: The researcher group used the formula used in the data analysis for forecasting inventory management of Chai Fah Kasetphan Co., Ltd. Four formulas are used as follows:

3.1 Last Period Demand: LPD. (Gryna, 2007; Jaw, 1995) This is a retrospective of chemical fertilizer distribution data. Set the equation t to be the time interval of the forecast formula data at *i*-1. The forecast value is equal to $\hat{Y}_i$ Shown as formula 1.1

$$\hat{Y}_i = Y_{i-1} = \;...\;(1.1)$$

Substitute $\hat{Y}_i$ = forecast value of chemical fertilizer sales period i,
Y_{i-1} = Historical data for forecasting chemical fertilizers during the period i-1

   3.2 Arithmetic mean (Arithmetic Average: AA) (Joseph, 2008; Jaw, 1 9 9 5) Bringing data on selling chemical fertilizers for the past 12 months in 2019 Configure the t equation is the average time of the data from cumulative division of values n get forecast value equal to $\hat{Y}_i$ or forecasting data in the future from the number of data i Shown as formula 1.2

$$\hat{Y}_i = \frac{Y_1 + Y_2 + Y_3 \dots Y_n}{n} = \frac{\sum_{i=1}^{n} Y_i}{n} \;..........................(1.2)$$

Substitute
   $\hat{Y}_i$ = Forecast value at interval i, Y_i = data value in the current period i,
   n = Cumulative amount of data used

   3.3 Moving Average (Moving Average: MA) (Joseph, 2008; Jaw, 1 9 9 5) Bringing the historical sales data of chemical fertilizers from January 2019 to December 2019 for 12 months determine the 3-month equation. Sales of chemical fertilizers from the 1st to the 3rd month and dividing the mean $n = 3$ will get the forecast value in the 4th month moving. Shown as formula 1.3

$$\hat{Y}_i = \frac{Y_{i-1} + Y_{i-2} + Y_{i-3} \dots + Y_{i-n}}{n} = \frac{\sum_{j=1}^{n} Y_{i-j}}{n} \;..................(1.3)$$

Substitute
   $\hat{Y}_i$ = Forecast value for period i, Y_{i-j} = the demand for chemical fertilizer distribution at the real time $i - j$
   n = Total number of moving average periods

3.4 Regression analysis (Regression Analysis: RA) (Aemo, 2020; Jaw, 1995)
   The formula of the linear regression relationship Basic equations for straight lines expressing demand $\hat{Y}_t$ It is a function of time (t) as shown in formula 1.4 (Joseph, 2008; Puk-in, 2019)

$$\hat{Y}_{t_i} = \alpha + \beta t_i \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1.4)$$

Substituting α is by the point of intersection of lines with vertical axis when $t_i = 0$ and β is the slope of the parameter line α and β then from the formula for finding the values as shown in Table 1

4. Forecasting absolute error: It is a function of the forecast error that can be analyzed quantitatively. This research uses complete tolerances (Mean Absolute Deviation : MAD) (Aemo, 2020; Sharma & Machiwal, 2021; Joseph, 2008; Jaw, 1995) which is a measure of the size of the forecast error regardless of the direction of the discrepancy and the data has the same units of measure as the observations. Shown as formula 1.5

$$(Mean\ Absolute\ Deviation : MAD) \frac{\sum_{i=1}^{n}(Y_i - \hat{Y}_i)}{n} \quad \dots\dots\dots\dots\dots(1.5)$$

Substitute $\hat{Y}_i$ = Forecast value at period i, Y_i = Demand value at interval i,

n = the amount of data taken to find the value of the time interval n ,

$(Y_i - \hat{Y}_i)$ = The deviation of the forecast value (Absolute Deviation)

RESULTS

From using the research formula for chemical fertilizer inventory management with forecasting methods of Chaifah Kasetphan Co., Ltd., the research group used data from chemical fertilizer sales from January 2019 to December 2019. It was found that the distribution of chemical fertilizers of 9 brands has a sales value of 482,430 sacks per year and has a working capital of more than 300 million baht per year. The data was analyzed in the last period demand (LPD) formula (Formula 1.1), Arithmetic means (AA) (formula 1.2), and Moving Average (MA) (Formula 1.3), Regression Analysis (RA) (Formula 1.4) and the formula for finding the absolute error (MAD) is shown as follows.

1. The research used data on the distribution of rabbit chemical fertilizer as an analysis sample in a computer program which will develop the formula and statistical analysis together with expert review. The research showing an example application of the Regression Analysis (RA) formula (Formula 1.4) is shown below.

Finding the value of β by preparing sales information from the 1st to the 12th month (January - December 2019) to prepare the information before entering the formula β as shown in Table 1

Table 1: the data preparation before the regression analysis formula was analyzed. (RA)

t	y	t.y	t^2	Y^2
1	32,888	32,888	1	1,081,620,544
2	18,000	36,000	4	324,000,000
3	14,147	42,441	9	200,137,609
4	23,065	92,260	16	531,994,225
5	44,756	223,780	25	2,003,099,536
6	45,049	270,294	36	2,029,412,401
7	37,341	261,387	49	1,394,350,281
8	30,245	241,960	64	914,760,025
9	18,830	169,470	81	354,568,900
10	15,129	151,290	100	228,886,641
11	9,891	108,801	121	97,831,881
12	15,586	187,032	144	242,923,396
78	304,927	1,817,603	650	9,403,585,439

Earn $n = 12$, $\sum_{i=1}^{n} t_i y_i = 1{,}817{,}603$, $\sum_{i=1}^{n} t_i = 78$, $\sum_{i=1}^{n} y_i = 304{,}927$

Earn $\sum_{i=1}^{n} t_i^2 = 650$, $\sum_{i=1}^{n} y_i^2 = 9{,}403{,}585{,}439$

Substitute
$$\beta = \frac{(n)\sum_{i=1}^{n} t_i Y_i - \left(\sum_{i=1}^{n} t_i\right)\left(\sum_{i=1}^{n} Y_i\right)}{(n)\sum_{i=1}^{n} t_i^2 - \left(\sum_{i=1}^{n} t_i\right)^2}$$

$$\beta = \frac{(12)(1{,}817{,}603) - (78)(304{,}927)}{(12)(650) - (78)^2} = 363.1$$

Substitute
$$\alpha = \bar{Y} - \beta \bar{t} = \frac{\sum_{i=1}^{n} Y_i - \left[\beta \sum_{i=1}^{n} t_i\right]}{n}$$

$$\alpha = \frac{(304{,}927) - ((363.1)(78))}{12} = 230{,}050.43$$

The researchers used the Sum Absolute Deviation data of the regression analysis formula which is equal to 130,446.3, substituted for formula 1.5 as follows:

$$(\text{Mean Absolute Deviation: MAD}) \quad = \quad \frac{130{,}446.3}{12} = 10{,}870.52$$

2. Forecast results of chemical fertilizers and comparison of actual chemical fertilizer sales values, the research group brought the sales value of chemical fertilizers of Chai Fah Kasetphan Company Limited in January 2020, there is a comparison gap (Gap) combined with the actual sales forecast for January 2020 equal to -23,361 sacks. It isn't unable to manage inventory due to insufficient forecasting of chemical fertilizers, sales and inventory are not available. The researcher then improve the forecast value by adding method, Weighted percentage values (formula 1.6 and 1.7) and compared with the actual sales value in February 2020 and the Gap was measured as shown in Figure 3 and shown in Table 2.

The formula 1.6: Weighted percentage is the data of the Gap value of each brand of chemical fertilizer divided by the sum of the forecast from the result of the Mean Absolute Deviation (MAD) and summarized as a percentage.

$$\text{Weighted percentage} = \frac{\text{= Gap of each brand of chemical fertilizers}}{\text{The sum of forecasts from good research results from values.MAD}} \times 100 \ldots\ldots\ldots(1.6)$$

The formula 1.7: Forecast sum values by combining the forecast values of chemical fertilizers in the brands of 2019, combined with the results of the values comparison field value (Gap)

Forecast sum value

$$= \textbf{Forecast value of the year 2019} + \textbf{Comparison field value (Gap)} \ldots\ldots\ldots\ldots(1.7)$$

actual sales price year 2020	33,624
forecast value	15,586
GAP January 2020	18,038
Distribution value year 2019	18,000
forecast sum+gap	33,624
(Gapx100)/sum	53.65
forecast value+ percentage value year 2019	9,656
62%+ forecast value	25,242
Actual sales price for of February	15,360
62% + forecast value - sum	-9,882

Figure 3: forecast improvement analysis by using weighted percentage increment method.

Table 2: the forecast results and the comparison of the actual sales of chemical fertilizers in January and February 2020

Brand chemical fertilizer	forecast value (sack)	Actual sales price in January 2020 (sack)	Effect of Weighted Percentage + Forecast Value (sack)	Actual sales price in February 2020 (sack)	Gap Comparison (Gap) (sack)
Rabbit Brand	15,586	33,624	25,242	15,360	9,882
Lotus Brand	657	1,692	1,982	908	1,074
Cow head brand	1,002	570	1,167	182	985
Flying Horse Brand	1,776	3,598	3,882	1,295	2,587
High-end brand	146	106	168	12	156
Maxi Fertilizer	219	627	695	377	318
Nok Pak Hang Brand	499	401	751	195	556
Yara Sailing Boat Brand	1,396	1,568	1,537	489	1048
Top One Brand	1,700	3,016	2,936	2,421	515
sum	22,981	45,202	38,360	21,239	17,121

From table 2: Shows the comparison of forecast values with actual sales of chemical fertilizers by comparison, it can be able to manage inventory management. For example, to improving the forecast value by increasing the weighted percentage of Rabbit chemical fertilizer brand, equal to 25,242 sacks. The actual sales value in February 2020 is 15,360 sacks. There are 9,882 sacks of chemical fertilizers in stock (from the comparison gap value (Gap)) and the improvement of forecast values by adding weighted percentage of Top One chemical fertilizer brand was equal to 2,936 sacks. The actual sales value in February 2020 is equal to 2,421 sacks. There is a stock of chemical fertilizer in stock equal to 515 (from the gap value (Gap)).

CONCLUSIONS AND DISCUSION

1. Research on warehouse management using forecasting methods of Chaifah Kasetphan Co., Ltd., the research group has visited the warehouse area. There were 9 brands of chemical fertilizer products with different sales figures. The research group therefore used the historical data for 12 months from January 2019 to December 2019, it was the data using for the forecast formula by choosing the number of 4 formulas which are Last Period Demand (LPD), Arithmetic Average (AA), Moving Average (MA), Regression Analysis (RA) and improvement of forecast values by adding percentage weight of chemical fertilizer By using the data of 2 main parts, namely the forecast value of 4 formulas and the sales value of the previous month (January 2020) were analyzed by the packaged program. The results showed that all 9 brands of chemical fertilizers after improvement, the weighted

percentage forecast value is 38,360 sacks. The actual distribution on February 2020 equals 21,239 sacks. The comparison gap (Gap) is 17,121 sacks. A positive value indicates that there is sufficient inventory for distribution. Therefore, this research can be used as information for inventory management of Chai Fah Kasetphan Co., Ltd.

2. Review the results of the experiment.

2.1 Agricultural in Uttaradit Province is diverse. (Statistics of Uttaradit Province. 2021)The research takes the problem of chemical fertilizer forecasting and the improvement of the weighted percentage forecast value to use in research. The data obtained from the research can be taken to store chemical fertilizer products and good inventories together with the use of data in labor planning, machine side, financial planning and accounting consistent with research of Cao, Y. & MaxShen, J. (2019)

2.2 Using forecast formulas: (Tian et al, 2021; Joseph & Aiello, 2008) The research group chose quantitative forecasting, because there is numerical data of the company in the past and can compare the complete discrepancy (MAD). There was a problem comparing the forecast value with the actual value from January 2020 sales, causing insufficient chemical fertilizer to be sold (negative value). Therefore, 2 additional formulas were used and managed well from the February 2020. The problems encountered may take into account the time period and used for research as well, which is consistent with the research of Guo, l et al, (2021) and Tian, X. et al (2021) and others. in using formulas and analysis in a ready-made computer program system.

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