

An Inventory Model for Local Dealers of Fertilizers

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Abstract

The study was undertaken to adopt a single item static inventory model for local dealers of fertilizers to facilitate continuous flow of fertilizer among the farmers following deterministic approach with the available data during 16 March 2008 to 15 March 2009. An attempt has been made to adopt an inventory model for fertilizer dealers of three unions of Gaibandha and Lalmonirhat districts so that an optimum stock of fertilizers could be known for smooth supply of fertilizers to local farmers. Optimum order quantity of urea inventory in Kharif I season was 14446 kg, 15549 kg and 13012 kg respectively for Kamardoho union (of Gaibandha), Mogolhat and Borobari unions (of Lalmonirhat). The optimum order quantity of inventory in Kharif II season was 25563 kg, 25694 kg and 26018 kg, respectively for Kamardoho, Mogolhat and Borobari union. Optimum order quantity in Rabi season was found 26693 kg, 30018 kg and 26514 kg, respectively, for Kamardoho, Mogolhat and Borobari union. The optimum cycle length of urea inventory in Kharif I season was 19 days, 19 days and 23 days for Kamardoho, Mogolhat and Borobari union, respectively. Again, optimum cycle length of inventory in Kharif II season was found at 11 days, 12 days and 12 days, respectively for Kamardoho, Mogolhat and Borobari union. Optimum cycle length of urea inventory in Rabi season was found as to be 10 days, 10 days and 11 days, respectively for Kamardoho, Mogolhat and Borobari union.

Key words : Inventory model, Fertilizer dealer, Optimum inventory level

1. Introduction

Agriculture is the dominant sector in the economy of Bangladesh. In past few decades fertilizer has been a crucial component of agricultural sector. Forty percent of total food grains are directly attributed to fertilizer use and on average eighty percent of total fertilizer sales is used for paddy. At present the major fertilizer being marketed in Bangladesh are Urea (46% nitrogen), Triple Super Phosphate (TSP) (46% phosphate), Single Super Phosphate (SSP) (14%-18% phosphate and 10% sulphur) and Muriate of Potash (MOP) (60% potash). In addition, some Ammonium Sulfate (20%-21% nitrogen), Gypsum (18% sulphur) and Zine (18% sulphur and 36% Zn) are being marketed (BBS, 2007).

Urea dominates the fertilizer consumption in Bangladesh. Consumption of urea increased from 559 thousand MT in 1980-81 to 1.3 million MT in 1990-91, 1.7 million MT in 1994-95 and 2.5 million MT in 2007-08. Consumption of urea was 66 percent of total fertilizer sales in 1994-95 and during the same period TSP, SSP and MOP sales were 5 percent, 20 percent and 6 percent respectively of the total fertilizer consumption (The Financial Express, 2008). Over the years TSP sale decreased and SSP sales increased substantially. Problem with fertilizer supply and distribution in Bangladesh has become a regular phenomenon and consequently much discussion has taken place on the availability and distribution of it.

Jaim and Islam (1996) alleged that defective fertilizer distribution system which created artificial crisis of Urea was mainly responsible for shortfall of Boro rice production in 1995. Based on macro level as well as micro level data, the study mainly aimed at investigating whether there were other important factors which aggravated the production environment in that year. The analysis showed that there was an absolute shortage of Urea supply during the peak period (January-March) of fertilizer demand in 1995 Boro season. Further, additional demand as a result of increased area under Boro paddy and high price of Aman rice at the end of 1994 also contributed to higher Urea price in 1995 Boro season. Increased fertilizer prices also caused significant reduction in its use which affected Boro production. The findings indicated that even under privatized distribution system, government intervention may be needed to ensure fertilizer at the right time, in the right quantity and at the right price.

Quasem (1978) examined the impact of the new system of distribution of fertilizer & irrigation equipment in Bangladesh. Limited evidence from the field survey conducted in eight upazilas of the country indicates that the availability of fertilizer has improved at least in the 1982-83 Boro season. It is, however, difficult to conclude that it is owing to the new system because supply of fertilizer up to the Primary Distribution points is eight with the Bangladesh Agricultural Development Corporation.

Availability of fertilizers at the right time, in the right quantity and at the right places is considered

crucial for expanding agricultural production. To make the supply of fertilizer easily available to the farmers, privatization of fertilizer distribution took place in phases; starting with the retail level in selected areas in the late seventies. Since then fertilizers are supplied through registered dealers at union levels. It is important to know that how much fertilizer need to be stocked, when to order for the next lot and what will be the optimum time between two orders.. The daily demand of fertilizers, set up cost of each purchase order and holding costs of inventory are the key factors that significantly influences the answers of the above questions. A fertilizer dealer must know the answers of these questions so that he/she could supply fertilizers smoothly among the farmers in his/her area of jurisdiction. Fortunately several inventory models are available. Unfortunately, no application of the model for determination of optimum level of inventory (i.e. economic lot size), reordering point and optimum cycle time of inventory for a local fertilizer dealers in Bangladesh has been reported as this study was limited to Bangladesh context. There is a need to know the exact amount of fertilizers to be stocked by a dealer for smooth sale to farmers. To help dealers to estimate correct amount of fertilizer need to be stocked, reordering point and cycle duration, this study has been conducted with a view to achieve the following objectives.

- i) To collect data from selected dealers on amount of urea sold per unit time as necessary to calculate parameters of the inventory model.
- ii) To adapt the inventory model for local dealers of fertilizers.
- iii) To apply the model to determine the optimum amount of urea need to be stocked, reordering point and cycle duration for a local fertilizer

dealer with a view to supply of fertilizer among the farmers smoothly.

2. Materials and Methods

2.1 The Inventory model

An inventory model is a tool or method of solving management problems. In other words, it is a tool for determination of sufficient stock in buffer or godown for the purpose of smooth supply of common items such as seed, fertilizers and pesticides. It is extremely difficult to develop a general inventory model that accounts for all variations in real systems. Indeed, even if a sufficiently general model can be formulated, it may not be analytically solvable. A good number of inventory models, both deterministic and stochastic, are available (Taha, 1985; Hillier and Lieberman, 2001). However to help dealers of agricultural inputs like fertilizers, a simple inventory model with a single item of deterministic demand could serve the purpose with fairly accurate result. This study was conducted with a single item deterministic inventory model (Taha, 1985) having constant demand and replenishment delay of two days.

The optimum order quantity is obtained in this model by the following standard equation (Taha 1985):

$$y^* = \sqrt{\frac{2K\beta}{h}} \dots\dots\dots (1)$$

Here, y^* = Optimum order quantity, units/order
 β = Demand, units/unit time
 K = Setup cost, Tk./unit inventory/order
 h = Holding cost, Tk./unit inventory/unit time

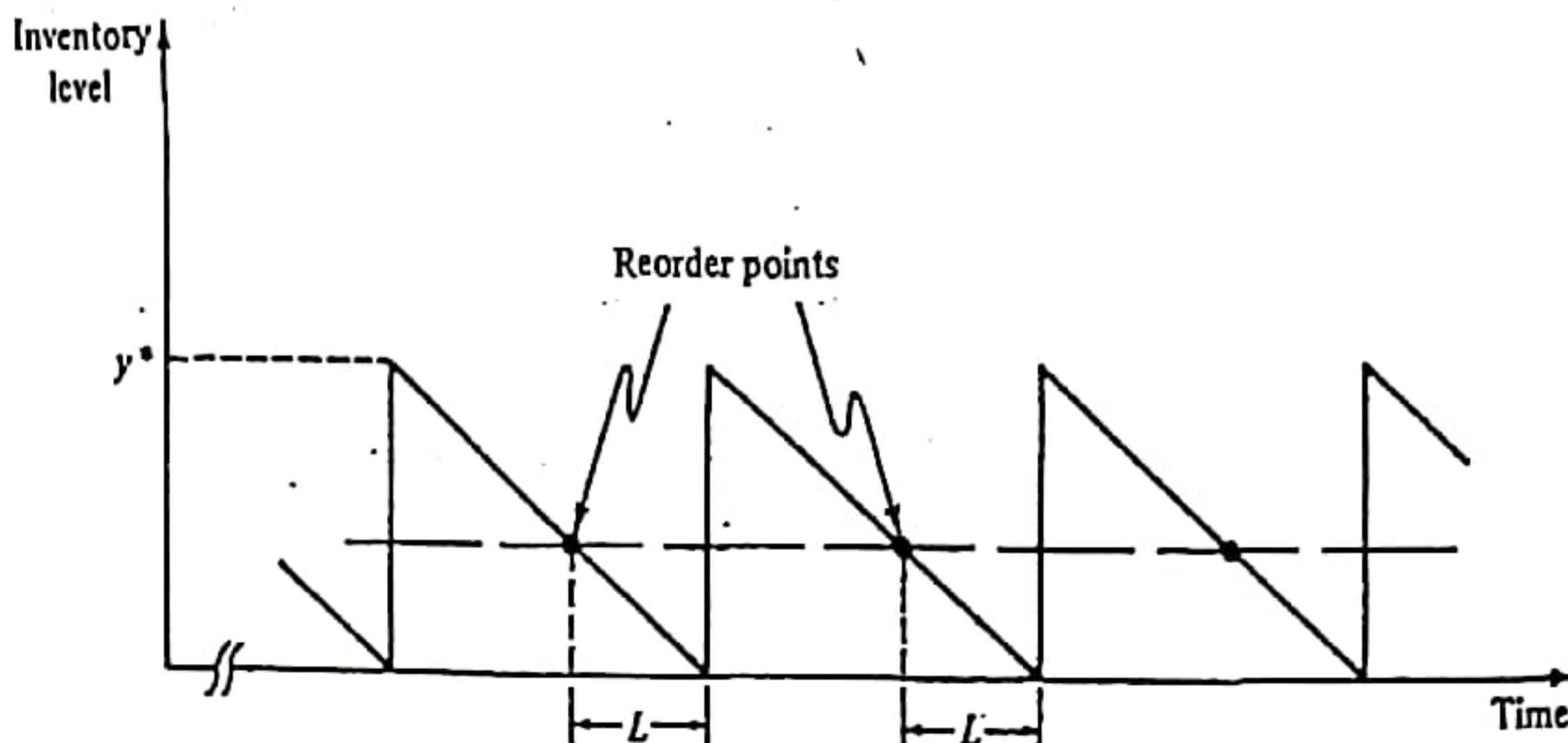


Fig. 1. The conceptual diagram representing the key parameters of the inventory model

and the optimum cycle length is obtained in the model by the following equation:

$$t_0^* = \frac{y^*}{\beta} \dots\dots\dots (2)$$

Here, t_0^* = Optimum cycle length

2.2 Study area

The study area was selected on the basis of land productivity of agricultural crops. The agricultural crops, mainly cereal crops rice, wheat and maize are grown in the study areas. Rice is the most popular grown product of this area. The three unions were selected for adaptation of the inventory model for urea fertilizer supply only. The unions were Kamardoho union of Gobindagonj Upazilla, Mogolhat and Borobari unions of Lalmonirhat Sadar. The data was collected from ten fertilizer dealers for calculation of the parameters of the inventory model as shown in equation no (1).

2.3 Selection of dealer

The aim of the study was to help the dealers to supply right amount of fertilizers at right time to farmers. The dealers are the agent who supplies fertilizer to the farmers. The selection procedure of dealers was based on their business reputation and availability of sales data. In other words, a total of ten dealers were selected who have responsiveness to the farmers to supply fertilizers at the right amount, at right time and at the right place.

2.4 Collection of data

Data were collected from the ten selected fertilizer dealers using direct contact method (i.e. face to face interview). In order to collect valid and reliable data, the data were collected from the dealers carefully keeping in mind the objectives of the study. The study was based upon the field data on urea sale during March 16, 2008 to March 15, 2009 as obtained from ten urea dealers of three unions of Bangladesh. From each union, 38, 27, and 27 data samples were collected for Rabi, Kharif-I and Kharif-II seasons, respectively.

2.5 Determination of daily demand

The daily demand of fertilizer was collected from the office records of the dealers. The dealers do not record fertilizer supply data by uniform interval of time. These data was recalculated to find out the average amount of fertilizer sold on daily basis. The daily demand of fertilizer (β) was calculated by straight line regression analysis of data.

2.6 Determination of setup cost

Setup cost (K) is the fixed cost incurred when an order is placed every time. Setup cost includes cost of preparation of document, managerial/office cost in designing, drafting, writing and dispatch of the purchase order. All the cost was collected from the dealers. Setup cost was determined per order per unit time. It is denoted by K .

2.7 Determination of holding cost

Holding cost is a variable cost. It includes house rent, current bill, security bill and miscellaneous cost. All the cost was collected from the dealers. Holding cost was determined per unit inventory per unit time. It is denoted by h .

2.8 Determination of optimum order quantity and optimum cycle length

Using the field data as collected from the dealers, the parameters of equation (1) i.e. K , β and h were calculated as describe above. The optimum order quantity (y^*) was calculated using equation (1). Similarly, the optimum cycle length (t_0^*) was obtained using equation (2).

3. Results

The study was undertaken to adapt an inventory model to find out optimum amount of fertilizers a dealer need to be stocked for smooth supply of fertilizers to farmers during the cropping seasons.

3.1 Calculation of holding cost (h)

Holding cost is a variable cost which includes house rent, electricity, security guard and miscellaneous costs. In this study only store rent and electricity cost were included in the holding cost. These data were collected from the selected fertilizer dealers. The information given by the dealers were used in calculation of the holding cost. Table 1 shows the holding costs of fertilizers in different locations in Tk per unit inventory per unit time.

3.2 Calculation of setup cost (K)

Setup cost (K) is a fixed cost incurred when an order is placed every time. Setup cost includes cost of preparation of document, managerial/office cost in designing, drafting, writing and dispatch of the purchase order. The setup cost per unit inventory per order of the fertilizer dealers were calculated from the information provided by the dealers during interview. These are shown in Table 1.

Table 1. The holding cost (h) and setup cost (K) of fertilizer dealers in different seasons in Kamardoho, Mogolhat and Borobari unions

Name of union	holding cost (h), Tk./inventory/unit time	setup cost (K), Tk./inventory/order
Kamardoho	0.184	2575
Mogolhat	0.02	3010
Borobari	0.01	1520

3.4 Calculation of daily demand (β)

The demand (sales) of fertilizer as collected from dealers were available at non-uniform interval of time. The available data was recalculated to find out the average demand of fertilizer on daily basis. As per definition of the deterministic inventory model the daily demand of fertilizer (β) was determined through straight line regression analysis for each crop season in different locations. The slope of the regression models as shown in Table 2 represents the daily demand (β) for the inventory model of equation (1) above. Three cropping seasons have been considered. These are: Kharif I, Kharif II and Rabi (Boro) season. The

length of Kharif I, Kharif II and Rabi (Boro) season are 16 March to 30 June, 01 July to 15 October and 16 October to 15 March, respectively.

3.5 Calculation of optimum order quantity (y^*) and optimum cycle length (t_0^*)

Using the value of daily demand, holding cost and setup cost to the equation (1), the optimum order quantity was calculated. Similarly, the optimum cycle length was also calculated using equation (2). The optimum order quantity (y^*), optimum inventory cycle (t_0^*) and reordering point for different cropping seasons are tabulated in Table 3.

Table 3 represents the optimum order quantity of urea inventory in Kharif I season was 14,446 kg, 15,549 kg and 13,012 kg respectively for Kamardoho, Mogolhat and Borobari union. Again, optimum order quantity of urea inventory in Kharif II season was found 25,563 kg, 25,694 kg and 26,018 kg respectively for Kamardoho, Mogolhat and Borobari union. Optimum order quantity of Rabi season was found to be 26,693 kg, 30,018 kg and 26,514 kg respectively for Kamardoho, Mogolhat and Borobari union.

Table 2. The model for daily demand (β) of urea fertilizer in different seasons in Kamardoho, Mogolhat and Borobari unions

Name of union	Seasons		
	Kharif I	Kharif II	Rabi
Kamardoho	$Y = 745.55X - 2757.50$	$Y = 2334.8X + 19790$	$Y = 2545.7X - 31558$
Mogolhat	$Y = 803.18X + 48977$	$Y = 2193.2X + 50599$	$Y = 2993.6X - 78810$
Borobari	$Y = 556.92X + 33993$	$Y = 2226.7X + 56000$	$Y = 2312.5X - 67148$

where, Y = Amount of urea sold, kg ; X = number of days

Table 3. Inventory indicators of urea fertilizers for Kamardoho, Mogolhat and Borobari unions

Name of union	Inventory decision indicators	Seasons		
		Kharif I	Kharif II	Rabi
Kamardoho	Optimum order quantity of urea (y^*), kg	14446	25563	26693
	Optimum inventory cycle (t_0^*), day	19	11	10
	Reordering point (when stock level come down to this amount), kg	1491	4670	5091
Mogolhat	Optimum order quantity of urea (y^*), (kg)	15549	25694	30018
	Optimum inventory cycle (t_0^*), day	19	12	10
	Reordering point (when stock level come down to this amount), kg	1606	4387	5987
Borobari	Optimum order quantity of urea (y^*), kg	13012	26018	26514
	Optimum inventory cycle (t_0^*), day	23	12	11
	Reordering point (when stock level come down to this amount), kg	1114	4454	4625

Optimum cycle length of urea inventory in Kharif I season was found 19 days, 19 days and 23 days respectively for Kamardoho, Mogolhat and Borobari union. On the other hand, optimum cycle length in Kharif II season was found at 11 days, 12 days and 12 days respectively for Kamardoho, Mogolhat and Borobari union. Optimum cycle length of Rabi season was found at 10 days, 10 days and 11 days respectively for Kamardoho, Mogolhat and Borobari union (Table 3).

For Kamardoho union, reordering point was found when the level of inventory of urea has reached 1,491 kg, 4,670 kg and 5,091 kg respectively for Kharif I, Kharif II and Rabi season. Again for Mogolhat union, reordering point was identified when the level of urea inventory reached 1,606 kg, 4,387 kg and 5,987 kg respectively for Kharif I, Kharif II and Rabi season. Again for Borobari union, reordering point was found when the level of inventory reached 1114 kg, 4454 kg and 4625 kg for Kharif I, Kharif II and Rabi season., respectively (Table 3).

4. Conclusions

The inventory model, if its parameters are estimated correctly, will help local dealers of fertilizers to determine the optimum level of inventory as well as reordering point in time so that farmers could receive right amount of fertilizer at right time. The model could easily be applied anywhere in Bangladesh if the location specific model parameters be known or calculated correctly. Sales data were collected from local dealers as a substitute of demand of urea of farmers. This limitation of the study could have been overcome if actual demand of urea of farmers of the locality be made available.

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