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Analysis of raw material inventory for insecticide packaging bottle with material requirement planning: a case study

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A B S T R A C T

PT. Agricon mostly produces 1L package (bottle) pesticides named Spontan insecticide. This study was conducted to analyze and determine the stock inventory of 1L bottles for determining an effective ordering schedule based on the calculation of safety stock and reorder points to optimize planning and inventory. Material Requirement Planning (MRP) method used to determine the effective scheduling of 1L bottle products. Material Requirement Planning is one method used to determine scheduling with advantages such as reducing inventory, reducing set up costs, and reducing idle time. The proposed order scheme for ordering 1L insecticide packaging bottle improve the company on reducing the frequency for ordering bottles from 7 times to 5 times and inventory is more stable and close to demand quantity.

1. INTRODUCTION

Raw material planning identically with scheduling, mainly the purpose of scheduling, manages inventory in the best way and within the optimal timeframe [1], [2]. PT. Agricon mainly produces 1L pesticide product, which has not implemented safety stock for inventory. When demand decreases, warehouse stock will increase because supplies didn't meet the demand, which is a loss for the company because of inventory cost or tied money. Lack of coordination in the planning division impacts some problems such as too much inventory, bad services, and not optimal capacity utilization [3], [4] Preventing that problem, proper planning, and material control is needed using Material Requirement Planning system [5], [6]. MRP is a manufacturing management system assisting manufacturers in dealing with production planning, scheduling, and inventory control [7], [8]. The advantages of the MRP method are cuts down and optimizes the inventory costs within a production period [9], purchase planning streamlines the production process [10], work scheduling [11], and time-saving [12].

Material Requirement Planning is a method for carrying out production planning to determine the order date and quantity of materials ordered to fill each product component [13], [14]. MRP system also provides appropriate information

about inventory and production [15], [16]. Material Requirements Planning aims to schedule raw materials, components, and sub-assemblies quantified in the correct quantity and ready at the right time [17], [18]. So MRP needs to keep 1L insecticide packaging bottle inventory meet reorder point and safety stock.

The company produces pesticides, fungicides, insecticides, and herbicides. The demand level is uncertain and not fixed per day, and the company is required to plan the production process sequences precisely to meet consumer needs. The company experienced problems such as high shipping and ordering costs, and raw material inventory was far less than inventory capacity.

The company must maintain raw materials availability such as 1L insecticide packaging bottle to expedite the production process. It was scheduling a 1L insecticide packaging bottle as its superior product needs to be done to determine the inventory amount in a certain period. The inventory can meet demand, knowing the safe amount of inventory to meet production needs optimally, and minimizing ordering costs by maximizing ordering capacity.

2. RESEARCH METHODS

One of the thriving markets that are The first step is Observations and interviews with operators and staff in order to understand the production process at PT. Agricon. Data collection will then continue, such as schedule receipt data, lead time, lot size, demand, truck capacity, and inventory data [19], [20]. Collected data processed using MRP. MRP is a method used for planning and control production and a tool for manage inventory depend on higher item levels [21], [22].

It is possible to get the raw materials needed to complete a product in the future demand using MRP. The company can optimize the required inventory, so it's not too much but not too small either [23]. MRP planning considers time priority to calculate material requirements and schedules supply to meet a product's demand [24].

MRP also considering production planning and computer-based inventory control system related to production scheduling and inventory control [25]. MRP related to production and inventory scheduling to ensure raw material planning must be precise to avoid excess or shortage inventory of raw material [26]. Here Table 1 is the format used in the MRP method.

Table 1. MRP

Item	Period				
Lead time	**1**	**…**	**…**	**…**	**t**
Gross requirement					
Schedule receipt					
Project on hand					
Net requirement					
Planned order receipt					
Planned order release					

MRP formulation and calculation [17]:

$$POH = Max\{0, POH(t-1) + SRt - GRt \quad (1)$$

$$NRt = Max\{0, GRt - POH(t-1) - SRt\} \quad (2)$$

$$PoRect = NRt \quad (3)$$

$$PoRelt = PoRect \quad (4)$$

The explanation of the notations in the formula: *it* is Gross Requirement on t-period, *SRt* is Schedule Receipt on t-period, *POHt* is Project On Hand on t-period, *NRt* is Net Requirement on t-period, *PoRect* is Planned Order Receipt on t-period, and *PoRelt* is Planned Order Release on t-period.

3. RESULTS AND DISCUSSION

PT. Agricon applies total product requirement in a month's production. 1L insecticide packaging bottle demand in July is 72,171 Units. The maximum storage capacity for a 1L insecticide packaging bottle is 100,000 Units. The total quantity available for the 1L insecticide packaging bottle on 1st July is 71,700 Units. Schedule receipt contains information about the quantity and date of raw material in-house. Table 2 below is the schedule receipt for some package.

Table 2. The arrival date of 1L insecticide bottle

Arrival date of 1l insecticide bottle					
200 ml		**500 ml**		**1000 L**	
Receipt date	**Units**	**Receipt date**	**Units**	**Receipt date**	**Units**
02/07	9078	02/07	5922	04/07	14000
02/07	8122	10/07	21000	12/07	5040
22/07	11000	10/07	9144	18/07	8050
		12/07	5856	19/07	15050
		12/07	1144	23/07	14560
		12/07	3736	26/07	7070
				30/07	110
				30/07	13590

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Safety stock calculation for 1L insecticide packaging bottle:
Value Z (95%) :1.65
Std deviation overall demand = 34,110
Lead Time = 11 days
$Safety\ Stock = Z * Std\ Deviation * \sqrt{LeadTime}$
= 1.65 x 34,11 x √11
= 18,667 units

Based on the calculation safety stock for the 1L insecticide packaging bottle is 18,667 Units. Below Table 3 is MRP calculation for 1L insecticide packaging bottle based on the gross requirement in July 2019 with total quantity 72,171 Units and opening stock (on Hand) is 71,700 Units.

Example:
Period 11
GRt = GR12 = 8008
SRt = SR12 = 5040
POH11 = 69687
POH12 =Max {0, POH(t-1) + SRt-GRt}
= Max {0, POH(11) + SR12 – GR 12}
= Max {0, 69687 + 5040 – 8008}
= 66719
NRt = Max {0, GRt-POH (t-1) – SRt}
NR11 = 0 (becuase POH (t-1) fulfill GRt)
PoRect = PoRect = 0
PoRelt = PoRelt = 0

MRP 1L insecticide packaging bottle calculation proposed considering various factors such as total request, store inventory capacity, safety stock, truck capacity, and reorder point. So schedule receipt calculation will be:
Total Gross Req in 1 month = 72.171 units
Store Capacity = 100.000units
Safety Stock = 18.667 units
Truck Capacity = 15.050 units
Demand every 11 days in/ Month = 3
Reorder point period 1 (1-11) = 34.680 units
Reorder point period 2 (12-23) = 66.824 units
Reorder point period 3 (24-30) = 26.668 units
Example reorder point period 1 calculation
Reorder Point = Safety stock + demand in t
Reorder Point = 18667 + 8008 + 8005 = 34680 units
The following Table 4 is the proposed MRP calculations on 1L insecticide packaging bottle.

Table 3. Calculation MRP 1L insecticide packaging bottle - the initial condition

Item: 1L bottle	**Period**								
Lead Time : 11	**1**	**2**	**3**	**4**	**. . .**	**27**	**28**	**29**	**30**
Gross requirement									
Schedule receipt				14000	. . .				13700
Project on hand	71700	71700	71700	85700	. . .	63299	63299	63299	76999
Net requirement	0	0	0	0	. . .	0	0	0	0
Planned order receipt									
Planned order release									

Table 4. Calculation MRP 1L insecticide packaging bottle – proposed

Item: 1L bottle	**Period**								
Lead time : 11	**1**	**2**	**3**	**4**	**. . .**	**27**	**28**	**29**	**30**
Gross requirement									
Schedule receipt									
Project on hand	71700	71700	71700	71700	. . .	74779	74779	74779	74779
Net requirement	0	0	0	0	. . .	0	0	0	0
Planned order receipt									
Planned order release									

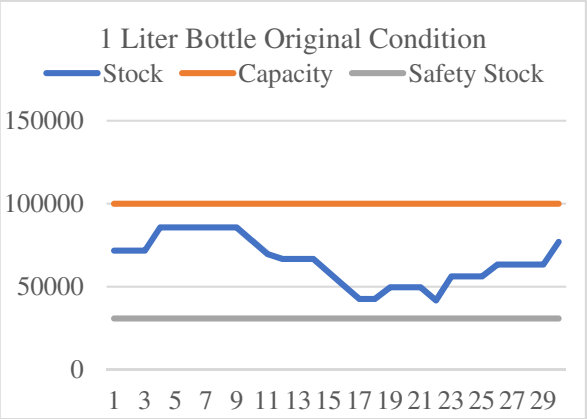

Fig. 1. 1L Bottle graph initial condition

Based on the MRP calculation for the 1L insecticide packaging bottle on initial condition in Fig. 1, the Net value requirement for each period is 0 because the previous quantity of schedule receipt can cover each period's gross requirement. Project On Hand has a high demand in the 10th – 24th period. On period 22nd, Hand's project has an unstable condition and close to the lowest quantity with a total Project on Hand 41,669 units. The vertical axis shows the units, and the horizontal axis shows the period.

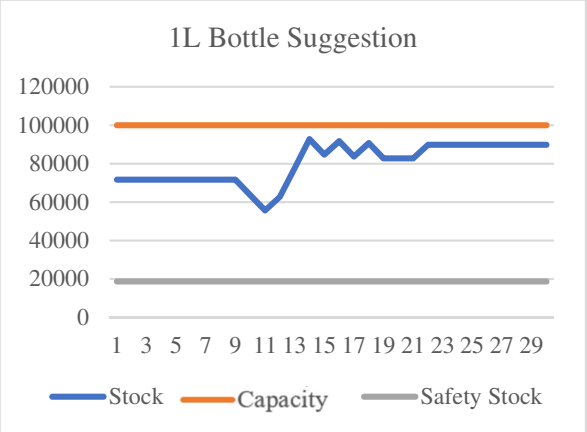

Fig. 2. 1L Bottle graph proposed condition

It considers various factors such as storage capacity, safety stock, demand, and truck capacity, and the proposed order scheme is used to improve or guide when making an order. Therefore, orders with considering inventory and demand will be more stable, shown in Fig. 2. Notice unstable demand in the company, then implement a three-period reorder point for 1L insecticide packaging bottle in a month. The reorder point for the 1st period is 34,680 units, where the company will make an order if inventory is less than the reorder point. The reorder point 2nd period is 66,824 units, and the reorder point 3rd period is 26,668 units.

The company only needs to order the bottle five times, compared to the previous condition needs seven times, where the company needs to make order seven times (2 times save). The other benefit is order and inventory are more stable close to demand. The following is a comparison chart using initial and proposed data in Fig. 3.

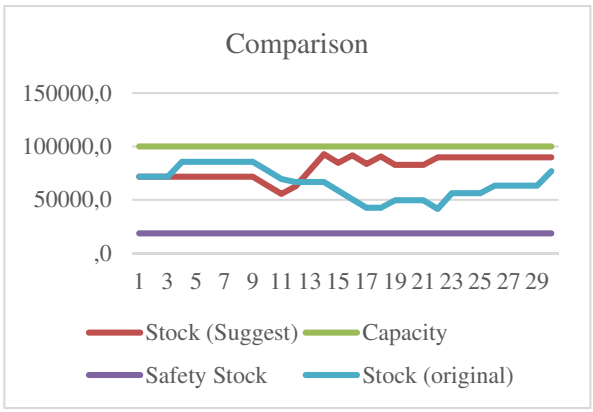

Fig. 3. Comparison of initial vs proposed

Research with the MRP method has been widely used in various industries, for example apparel [6], paper [11], cement [12], automobile [13], garment [15], construction [16], motorcycle chains [17], talc powder [18], screen printing ink [19], briquette [20], sewing thread [21], pharmaceuticals [22], alloy cast [23], and coconut sugar [24]. The majority of existing research discusses the raw materials for making finished products. There are not many studies that discuss packaging. Packaging supplies are important because they complement the products being marketed, and the amount must meet the amount of products. Excess packaging inventory increases storage costs, and a shortage of packaging inventory hinders the packaging process. In addition, proper ordering frequency can reduce the cost incurred by the company.

4. CONCLUSION

The proposed order scheme for ordering 1L insecticide packaging bottle improve the company on reducing the frequency for ordering bottles from 7 times to 5 times and inventory is more stable and close to demand quantity. In future research, MRP calculations can be carried out by comparing various methods and conducting a

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sensitivity analysis of the proposed results. PT. Agricon has not implemented an ordering system for raw material of 1L pesticide bottles using safety stock. This impact on inventory accumulation occurs in the warehouse (waste of inventory). Project On Hand on 10^{th} – 24^{th} period for 1L insecticide packaging bottle is not stable because inventory vs demand not precisely catches. Implemented safety stock and reorder points will improve the inventory control and make it more durable.

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