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Research paper

Dynamic Programming to Solve Picking Schedule at the Tea Plantation

Siti Mahsanah Budijati[1]*, Bermawi Priyatna Iskandar[2]

[1]*Industrial Engineering Department, Faculty of Industrial Technology, Universitas Ahmad Dahlan, Yogyakarta, Indonesia*
[2]*Industrial Engineering, Faculty of Industrial Technology, Institut Teknologi Bandung, Indonesia*
**Corresponding author E-mail: smbudijati@ie.uad.ac.id*

Abstract

The tea picking schedule at PT Perkebunan Ciater is set to be the same for all plantation blocks. In fact, the altitude from sea level and the pruning age of each plantation block is different, this results in the difference of buds' growth. The implementation of the same picking schedule causes the quality and quantity of tea buds often could not be fulfilled. This research is to determine the precise picking schedule by considering the buds' growth of each plantation block. Two steps are implemented to solve the problem. The first step is to look for picking period and the pattern of buds' quality for each plantation block, which corresponds to the altitude of the location and the pruning age. The regression method is applied in this first step. The buds' quality pattern is then used to determine the cost of decreasing buds' quality and the costs of the buds that left in the plantation. The second step is to develop the picking schedule using dynamic programming, which minimizes the total cost of picking. In addition to this, we also develop a rolling schedule, which schedule time interval is three days. The model results show that the proposed schedule gives a better total cost than the current schedule and the buds' quality target is easier to achieve.

Keywords: *Dynamic Programming; Minimizes Cost; Picking Schedule.*

1. Introduction

Quality is one of the key competitions in marketing of a product. Tea is one of the products that relies on quality as the key competition in its marketing. Most of the products of tea plantation in Indonesia are intended for export and the marketing process is arranged by an auction system. In this auction system, the product quality is a crucial factor for product pricing.

A tea plantation applies quality and quantity standards in the harvesting of tea. In order to meet the expected standards, the company arranges the tea picking schedule. The arrangement of picking schedule is adjusted to the growth of tea bud. Meanwhile, the growth of tea bud, among others, is affected by the altitude from sea level and the pruning age.

The tea picking schedule at PT Perkebunan Ciater is set to be same for all plantation blocks, that is every 12-14 days. In fact, the altitude from sea level and the pruning age of each plantation block is different, this results in a difference of bud growth. The implementation of the same picking schedule causes the quality and quantity of tea buds often could not be fulfilled.

Therefore, it is necessary to determine the precise picking schedule by considering the bud growth of each plantation block. In addition, it is also necessary to arrange the picking reschedule for updating if the picking plan could not be implemented.

Dynamic programming is one of the methods that can be used to solve scheduling problem. Some research showed the implementation of dynamic programming in the scheduling problems, among others [1] proposed dynamic programming heuristic solution procedure to study the utilization of outsourcing as a way to overcome the supply chain disruptions in production scheduling in the presence of sudden consumer orders. Meanwhile [2] applied dynamic programming to schedule surgery at the hospital in order to minimize the waiting time between patient requests and surgery schedules, overtime hours in the operating room and availability of bed in wards. [3] implemented pseudo-polynomial dynamic programming to minimize the number of tardy weighted jobs, determining the due dates, resources allocation as well as batch delivery costs. Moreover [4] used the dynamic programming to schedule aircraft landings on a single runway in both static and dynamic problem. [5] proposed an exact algorithm based on dynamic programming to find optimal sequences for the job-shop scheduling problem. [6] developed a stochastic dynamic programming model to optimize aircraft replacement scheduling by taking into consideration the fluctuations in the market demand and the status of the aircraft. Furthermore [7] developed approximate dynamic programming (ADP) algorithms to solve stochastic project scheduling problems. [8] developed adaptive dynamic programming algorithms to schedule consecutive appointments with the consideration of patient preferences in order to maximize the patient satisfaction level. [9] proposed a new dynamic programming algorithm for solving scheduling problem of independent tasks with common due date and to minimize the total weighted tardiness.

In addition, dynamic programming is also used for problem solving on technology replacement related to capacity planning as in [10]. Moreover [11] developed dynamic programming as a method of controlling demand through the pricing of delivery time at an e-grocer receiving orders via online booking system. Meanwhile [12] developed dynamic programming model for environmental decision-making process in coal mining investment. Related to layout optimization [13] proposed a new model based on dynamic programming to make a trade-off between reliability and cost for the layout design. As for [14] applied dynamic programming in assembly line balancing especially for solving resource constrain.

Some authors used dynamic programming to solve inventory problems, such as [15] used dynamic programming to complete a stochastic multi period inventory replenishment problem on supplier in a reverse supply chain. [16] used forward approximate dynamic programming to find out the solution of a multi locations stochastic inventory system. [17] developed model based on dynamic programming for a finite horizon single product inventory with uncertain probability distribution demand. Meanwhile [18] applied algorithm that reformulated the dynamic programming recursion as a mixed integer linear programming in the inventory scheduling problem.

In the knapsack problems, some authors considered the uses of dynamic programming too, that is [19] proposed a dynamic programming algorithm for the knapsack problem with setup that common in production planning applications, [20] developed two dynamic programming algorithms where the first algorithm was proposed for linear complexity on the number of items, while the latter was used for linear complexity at the knapsack capacity. Moreover [21] proposed a dynamic programming algorithm for knapsack packing with minimum cost and knapsack covering with maximum profit.

Other research area that uses dynamic programming was routing and transportation. [22] proposed a dynamic programming model to minimize transportation cost for multimodal transport operator. [23] combined a dynamic programming and ant colony optimization for emergency materials transportation model development in disasters situation. Moreover [24] offered an ADP approach to optimize time for handling and determine space to store in a coil warehouse. Meanwhile [25] proposed a markovian decision model and ADP to solve vehicle routing problem for emissions minimization, whereas [26] combined a genetic algorithm and exact dynamic programming procedure for green vehicle routing and scheduling problem.

Dynamic programming is used to manage at a plantation too. [27] showed the use of the model to optimize replanting policy that considerate CO2 emission and commercial benefits. In this paper dynamic programming was used to propose tea picking schedule which minimizes the total cost of picking.

2. Model Development

2.1. Notation of the model

The notations used in the model are:

Decision variable

x_{ni} : the weight of tea buds picked in period n, at the plantation block i, which the buds are picked according to the picking schedule.

$y_{(n-a)i}$: the weight of tea buds picked in period n, at the plantation block i, which the buds are the residual from picking period n-a

a = 1 or 2 (delays since period n)

Supply side

s_{ni} : tea buds availability in period n, at the plantation block i (which is available on picking schedule)

S_n : the total of tea buds availability in period n, at all plantation blocks

$$S_n = \sum_{i=1}^{I} s_{ni} \tag{1}$$

$l_{(n-a)i}$: the residual tea buds from period n-a, at the plantation block i

$L_{(n-a)}$: the total of residual tea buds from period n-a, at all plantation blocks

$$L_{n-a} = \sum_{i=1}^{I} l_{(n-a)\,i} \tag{2}$$

G_{n-1} : the total of residual tea buds from all periods before period n

$$G_{n-1} = L_{n-2} + L_{n-1} \tag{3}$$

l_{ni} : the residual tea buds in period n, at the plantation block i

$$l_{ni} = s_{ni} - x_{ni} \tag{4}$$

L_n : the total of residual tea buds in period n, at all plantation blocks

$$L_n = \sum_{i=1}^{I} l_{ni} \tag{5}$$

G_n : the total of residual tea buds in the end of period n

$$G_n = L_{n-1} + L_n \tag{6}$$

Demand side

d_n : the demand of period n

Picking cost

$C_{ni}(x_{ni})$: picking cost of x tea buds in period n, at plantation block i

$B_{(n-a)i}(y_{(n-a)i})$: picking cost of residual y tea buds in period n, at plantation block i, which the buds are the residual from picking period n-a

The picking cost is consist of:

Labor cost (C_L)

$$C_L = r_i \cdot z_i \tag{7}$$

r_i : the labour wage of each kg of tea buds at plantation block i, based on the picking capacity and buds' analysis results

z_i : the weight of tea buds picked at the plantation block i

Transportation cost (C_j)

Transportation cost is determined by the distance from the plantation block i to the factory and the number of trucks. Truck capacity is 2000 - 2500 kg of tea buds. Each truck is only used for one plantation block.

The function of transportation cost is:

$$C_j = \begin{cases} 1359 \,.\, H_i & \text{for } 0 < z_i \leq 2500 \\ (2 \,.\, 1359).\, H_i & \text{for } 2500 < z_i \leq 5000 \\ (3 \,.\, 1359).\, H_i & \text{for } 5000 < z_i \leq 7500 \\ & \text{etc.} \end{cases} \tag{8}$$

H_i : the distance from the plantation block i to the factory

Thus, the picking cost is the labour cost plus transportation cost, namely:

$$C_{ni}(x_{ni}) = C_L + C_J \tag{9}$$

$$B_{(n-a)i}(y_{(n-a)i}) = C_L + C_J \tag{10}$$

Losses cost

T_{ni} : losses cost due to the percentage of old buds picked more than 30% in period n, at the plantation block i, which the buds are picked according to the picking schedule.

$T_{(n-a)i}$: losses cost due to the percentage of old buds picked more than 30% in period n, at the plantation block i, which the buds are the residual from picking period n-a

Assume: the number of broken buds is 5%, if the old buds increased by 1% or the number of the old buds 31%, then the percentage of good buds fell 1% or remaining to 64%.

O_n : losses due to remaining buds at the plantation block in period n (because of incomplete picking at a plantation block in one day), where the losses depend on buds growth rate.

Index

n : period = 1, 2, 3,…, N

i : plantation block = 1, 2, 3, …, I

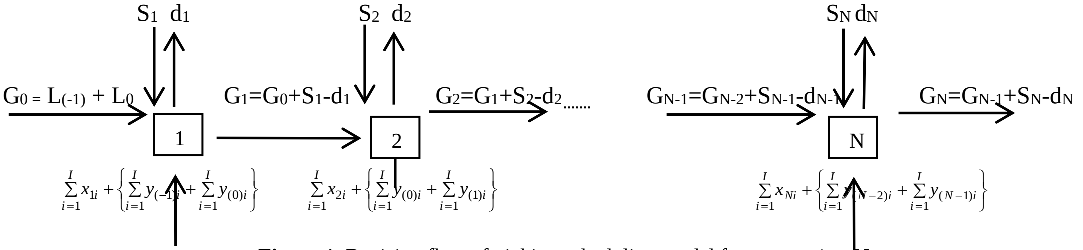

Figure 1. Decision flow of picking scheduling model from stage 1 to N

2.2. Description of decision flow

From Figure 1 it can be explained that in stage (period) 1 there is a supply of tea buds, namely S_1 (the total of tea availability in period 1, at all plantation blocks) that can be picked in period 1 according to the age of picking. Meanwhile, there are also supplies of tea buds from the remaining of 2 consecutive periods before period 1 ($G_0 = L_{(-1)} + L_0$). Moreover, the demand of period 1 is d_1. With the supplies S_1 and G_0 as well as the demand d_1, the decision variable for period 1 is $\sum_{i=1}^{I} x_{1i} + \left\{\sum_{i=1}^{I} y_{(-1)i} + \sum_{i=1}^{I} y_{(0)i}\right\}$ which means that the demand is fulfilled from three sources: (i) the sum of tea buds picked from plantation blocks 1 to I with picking age according to the picking schedule ($\sum_{i=1}^{I} x_{1i}$); (ii) tea buds picked from plantation blocks 1 to I, which are the residual of picking from one previous period ($\sum_{i=1}^{I} y_{(0)i}$); (iii) tea buds picked from plantation blocks 1 to I, which are the residual picking from two previous periods ($\sum_{i=1}^{I} y_{(-1)i}$). So, at the end of period 1, the remaining tea buds in the plantation blocks are G_1 which can be used as a supply for period 2. Furthermore, with the same procedure for the decision flow of the next stages.

2.3. Model formulation

This model is a modification of inventory-production dynamic model. Thus, the formulation of dynamic programming is:

The objective function: $f_n(G_n)$

The minimum cost of tea picking from period 1 to period n, if there are a number of tea buds remaining in the plantation block (G_n) at the end of the picking period.

$$G_n = G_{n-1} + S_n - d_n \quad (11)$$

$$G_{n-1} = G_n - S_n + d_n \quad (12)$$

Recursive function:

$$f_n(G_n) = \min_{\substack{0 \le \sum_{i=1}^{I} x_{ni} \le S_n \\ 0 \le \sum_{a=1}^{2}\sum_{i=1}^{I} y_{(n-a)i} \le G_{n-1}}} \left\{ \begin{array}{l} \sum_{i=1}^{I} C_{ni}(X_{ni}) + \sum_{i=1}^{I} T_{ni}.X_{ni} + \\ \sum_{a=1}^{2}\sum_{i=1}^{I} B_{(n-a)i}(y_{(n-a)i}) + \sum_{a=1}^{2}\sum_{i=1}^{I} (T_{(n-a)i}.y_{(n-a)i}) + \\ O_n(G_{n-1} + S_n - d_n) + f_{n-1}(G_{n-1}) \end{array} \right\} \quad (13)$$

I: picked plantation blocks

$C_{ni}(X_{ni})$ given by (9)

$B_{(n-a)i}(y_{(n-a)i})$ given by (10)

G_{n-1} given by (3) or (12)

The boundary conditions at N = 1

$$f_1(G_1) = \min_{\substack{0 \le \sum_{i=1}^{I} x_{1i} \le S_1 \\ 0 \le \sum_{a=1}^{2}\sum_{i=1}^{I} y_{(1-a)i} \le G_0}} \left\{ \begin{array}{l} \sum_{i=1}^{I} C_{1i}(X_{1i}) + \sum_{i=1}^{I} T_{1i}.X_{1i} + \\ \sum_{a=1}^{2}\sum_{i=1}^{I} B_{(1-a)i}(y_{(1-a)i}) + \sum_{a=1}^{2}\sum_{i=1}^{I} T_{(1-a)i}(y_{(1-a)i}) + \\ + O_1(G_0 + S_1 - d_1) \end{array} \right\} \quad (14)$$

3. Model Analysis

The picking schedule is arranged for every 3 periods (days), if the result of first day picking is known, then the picking schedule is updated for the next 3 days (the scheduling of period 2 to 4), and so on until the end of the picking period. The range of picking schedule within 3 days is based on the growth rate of tea buds.

The first step in this model analysis is to determine the pattern of buds' quality for each plantation block. The regression method is applied in this first step to obtain the equation of buds' decreasing quality that displayed in Table 1.

Table 1: The equation of buds' decreasing quality

The altitude from sea level	Pruning age	The equation of buds' decreasing quality
plateau (> 1200 m)	TP 1 (4 – 12 month)	$X = e^{3.336 + 0.00798\ t}$
	TP 2 (13 – 24 month)	$X = 26.88 + 0.305\ t$
	TP 3 (25 – 36 month)	$X = e^{3.384 + 0.00537\ t}$
	TP 4 (37 – 48 month)	$X = 28.596 + 0.193\ t$
plains (900 – 1200 m)	TP 1 (4 – 12 month)	$X = e^{3.3394 + 0.0089\ t}$
	TP 2 (13 – 24 month)	$X = 27.3031 + 0.3053\ t$
	TP 3 (25 – 36 month)	$X = e^{3.38099 + 0.00511\ t}$
	TP 4 (37 – 48 month)	$X = e^{3.3867 + 0.00484\ t}$
lowland (600 – 900 m)	TP 1 (4 – 12 month)	$X = e^{3.165 + 0.0202\ t}$
	TP 2 (13 – 24 month)	$X = 21.05 + 0.7125\ t$

Note: x is the percentage of old buds

t is period (day)

The percentage of old buds increases with increasing days, which means the quality of buds decreases.

To ilustrate model analysis as the second step of picking schedule model development, we used some data, namely: demand of buds, picking planning, the percentage of old buds for each plantation block, and the tea buds availability of each plantation block that are shown in Tables 2, 3, 4, and 5, respectively.

Table 2: Demand of the buds (kg)

Period (n)	1	2	3	4	5	6
Demand (d_n)	8000	9000	8000	9000	9000	11000

In addition, it is known that the picking capacity of each labour is 40 kg and the picking wage of each kg is Rp160,00 (with the content of buds in good condition of 65% and 30% old buds).

Tabel 3: The picking planning

No	Name of block	Distance from factory (km)	The altitude from sea level (m)	Purning age (month)	The day of picking	date						The remaining buds (kg)
						3	4	5	6	7	8	
1	Dawuan I	5	1175	39	7	9	10	11	3000	1	2	
2	Dawuan II	5	1105	44	10	11	12	13	14	2500	2500	
3	Cinampel	7	1110	5	12	13	14	15	16	2000	3000	
4	Belendung II	7	1190	25	13	3500	5000	4000	3	4	5	
5	Wates	10	1500	35	Picking day	1000	2	3	4	5	6	
6	Panorama	9	1285	53	12	13	14	15	16	1500	3500	3500
7	Talaga	6	1335	47	13	14	15	2000	4000	1000	3	
8	Cicenang	7	1360	45	17	3500	4000	2000	3	4	5	
9	Sela Batu	5	1350	6	9	10	11	12	2000	2000	2000	
	Total (kg)					8000	9000	8000	9000	9000	11000	

Tabel 4. The percentage of old buds for each plantation block

No	Name of block	Group of altitude and pruning age	percentage of old buds						
					date				
			3	4	5	6	7	8	9
1	Wates	plateau, TP 3	31.96	finished picking					
2	Belendung II	plains, TP 3	31.58	31.74	31.9	finished picking			
3	Cicenang	plateau, TP 4	32.07	32.26	32.46	finished picking			
4	Talaga	plateau, TP 4	have not been picked		31.68	31.88	32.07	finished picking	
5	Dawuan I	plains, TP 4	have not been picked			31.34	31.49	31.64	finished picking
6	Sela Batu	plateau, TP 1	have not been picked			31.18	31.43	31.68	finished picking
7	Dawuan II	plains, TP 4	have not been picked				31.79	31.95	32.1
8	Cinampel	plains, TP 1	have not been picked				32.81	33.1	33.4
9	Panorama	plateau, TP 4	have not been picked				31.88	32.07	32.26

The provision of losses costs due to tea buds picked does not match the standard of quality, there is a policy of reducing wages per kg, consisting of:

1. Reduction of Rp 3,00/kg for each 1% decreasing of buds' quality from 70% to 62% or old buds of 25% to 33%.
2. Reduction of Rp 6,00/kg for each 1% decreasing of buds' quality from <62% to 60% or old buds of > 33% to 35%.
3. Reduction of Rp 9,00/kg for each 1% decreasing of buds' quality from <60% to 56% or old buds of > 35% to 39%.

Table 5: The tea buds availability of each plantation block

Period (n)	Name of block (i)	tea buds availability (s_{ni}) in kg
0	Wates (must be picked)	1000 (G_0)
1	Belendung II	12500 (s_{11})
	Cicenang	9500 (s_{12})
3	Talaga	7000 (s_{31})
4	Dawuan I	3000 (s_{41})
	Sela Batu	6000 (s_{42})
5	Dawuan II	5000 (s_{51})
	Cinampel	5000 (s_{52})
	Panorama	8500 (s_{53})

Furthermore, by applying equations (1) to (14), the solutions are obtained. For the boundary condition N=1, the solution is displayed in Table 6. For N=2, the solution is displayed in Table 7, and for N=3, the solution is displayed in Table 8.

To illustrate the results of the calculation, an example is given for the stage 1 of the first possible decision (first row, Table 6). For the stage 1, there is a supply of G_0=1000 (must be picked) plus supply of s_{11}=12500 and s_{12}=9500. Demand of the period 1 (d_1)=8000, then one of the possible decision is y_{01}=1000 (must be picked); x_{11}=0 (there is no picking from s_{11}); and x_{12}=7000 (picking from s_{12}), so the remaining tea buds in plantation blocks are l_{11}=12500 and l_{12}=2500.

The costs needed for the picking are:

{Labor costs according to buds quality at each plantation block} + {transportation costs from each plantation block to the factory, according to the distance of each plantation block} + {cost of decreasing quality of the tea buds from each plantation block} + {loss due to remaining buds in each plantation block}

So the cost of picking for the first optimal decision in the stage 1 is:

{(160 – (1.962 × 3)) ×1000} + {10 ×1359 ×1} + {1.962 × 3 ×1000} + {(160 – (2.07 × 3)) ×7000}+ {7 × 1359 × 3} + {2.07 × 3 × 7000} + {(31.742 – 31.58) ×3 ×12500} + {(32.263 – 32.07) ×3 × 2500} = 1,329,651.5

Then, by tracing the solution from Tables 6 to 8 in backward way, the result of picking schedule for the first 3 days, presented in Table 9 with the total cost is **Rp. 4,130,207.50**

To illustrate the cost comparison between the solution of the model and the original picking plan, it can be seen again the picking planning in Table 3. If the original plan is implemented, then the cost of picking that must be issued is:

(i) period 1 :

{((160 – (1.962 × 3))×1000) + (10 × 1359 ×1) + (1.962 × 3 × 1000)} + {((160 – (1.58 × 3)) × 3500) + (7 × 1359 × 2) + (1.58 × 3 × 3500)} + {((160 – (2.07 × 3)) × 3500) + (7 × 1359 × 2) + (2.07 × 3 × 4500} + {(31.742 – 31.58) × 3 × 9000} + {(32.263 – 32.07) × 3 × 6000} = 1,339,490

(ii) period 2 :

1,339,490 + {((160 – (1.742 × 3)) × 5000) + (7 ×1359 × 2) + (1.742 × 3 × 5000)} + {((160 – (2.263 × 3)) × 4000) + (7 ×1359 × 2) + (2.263 × 3 × 4000)} + {(31.9 – 31.742) × 3 × 4000} + {(32.46 – 32.263) × 3 × 2000} = 2,820,620

(iii) period 3 :

2,820,620 + {((160 – (1.9 × 3)) × 4000) + (7 ×1359 × 2) + (1.9 × 3 × 4000)} + {((160 – (2.46 × 3)) × 2000) + (7 ×1359 ×1) + (2.46 × 3 × 2000)} + {((160 – (1.69 × 3)) × 2000) + (6 ×1359 ×1) + (1.69 × 3 × 2000)} + {(31.88 – 31.69) × 3 × 5000} = **4,140,163**

So, if the original plan is implemented, then the picking schedule for the first 3 days is as in Table 10.

Tabel 6: The solution of f_1 for picking schedule of N=1

stage	Input variable			Possible decisions			Optimal decision			Output variable G_1		Value of possible decisions (Rp)	Value of optimal decision (Rp)
	G_0	S_1											
	l_{01} (must be picked)	s_{11}	s_{12}	y_{01}	x_{11}	x_{12}	y_{01}	x_{11}	x_{12}	l_{11}	l_{12}		
1	1000	12500	9500	1000	0	7000	1000	0	7000	12500	2500	1,329,651.5	1,329,651.5
	1000	12500	9500	1000	2500	4500	1000	2500	4500	10000	5000	1,329,884	1,329,884
	1000	12500	9500	1000	5000	2000	1000	5000	2000	7500	7500	1,330,116.5	1,330,116.5
	1000	12500	9500	1000	7000	0	1000	7000	0	5500	9500	1,330,302.5	1,330,302.5
	1000	12500	9500	1000	4500	2500	1000	4500	2500	8000	7000	1,330,070	1,330,070
	1000	12500	9500	1000	2000	5000	1000	2000	5000	10500	4500	1,329,837.5	1,329,837.5

Tabel 7: The solution of f_2 for picking schedule of N=2

stage	Input variable G_1		Possible decisions		Optimal decision		Output variable G_2		Value of possible decisions (Rp)	Value of optimal decisions (Rp)
	l_{11}	l_{12}	y_{11}	y_{12}	y_{11}	y_{12}	l_{11}	l_{12}		
2	12500	2500	6500	2500	6500	2500	6000	0	1329651.5 + 1480968 = 2810619.5*	2,810,619.5
	10000	5000	4000	5000					1329884 + 1480968 = 2810852	
	7500	7500	1500	7500					1330116.5 + 1480968 = 2811084.5	
	8000	7000	2000	7000					1330070 + 1480968 = 2811038	
	10500	4500	4500	4500					1329837.5 + 1480968 = 2810805.5	
	5500	9500	0	9000			5500	500	1330302.5 + 1481014.5 = 2811317	2,810,852
	8000	7000	2500	6500					1330070 + 1481014.5 = 2811084.5	
	10500	4500	5000	4000	5000	4000			1329837.5 + 1481014.5 = 2810852 *	
	12500	2500	7500	1500	7500	1500	5000	1000	1329651.5 + 1481061 = 2810712.5 *	2,810,712.5
	10000	5000	5000	4000					1329884 + 1481061 = 2810945	
	7500	7500	2500	6500					1330116.5 + 1481061 = 2811177.5	
2	5500	9500	1500	7500			4000	2000	1330302.5 + 1481154 = 2811456.5	2,810,991.5
	8000	7000	4000	5000					1330070 + 1481154 = 2811224	
	10500	4500	6500	2500	6500	2500			1329837.5 +1481154 =2810991.5 *	
	12500	2500	9000	0	9000	0	3500	2500	1329651.5 + 1481200.5 = 2810852 *	2,810,852
	10000	5000	6500	2500					1329884 + 1481200.5 = 2811084.5	
	7500	7500	4000	5000					1330116.5 + 1481200.5 = 2811317	
	5500	9500	2500	6500			3000	3000	1330302.5 + 1481247 = 2811549.5	2,811,084.5
	8000	7000	5000	4000					1330070 + 1481247 = 2811317	
	10500	4500	7500	1500	7500	1500			1329837.5 + 1481247 =2811084.5 *	
	10000	5000	7500	1500	7500	1500	2500	3500	1329884 + 1481293.5 = 2811177.5 *	2,811,177.5
	7500	7500	5000	4000					1330116.5 + 1481293.5 = 2811410	
2	5500	9500	4000	5000			1500	4500	1330302.5 + 1481386.5 = 2811689	2,811,224
	8000	7000	6500	2500					1330070 + 1481386 = 2811456	
	10500	4500	9000	0	9000	0			1329837.5 + 1481386.5 = 2811224 *	
	10000	5000	9000	0	9000	0	1000	5000	1329884 + 1481433 = 2811317 *	2,811,317
	7500	7500	6500	2500					1330116.5 + 1481433 = 2811549.5	
	5500	9500	5000	4000			500	5500	1330302.5 +1481479.5 = 2811782	2,811,549.5
	8000	7000	7500	1500	7500	1500			1330070 + 1481479.5 = 2811549.5 *	
	7500	7500	7500	1500	7500	1500	0	6000	1330116.5 + 1481526 = 2811642.5 *	2,811,642.5

Tabel 8: The solution of f_3 for picking schedule of N=3

stage	Input variable			Possible decision			Optimal decision			Output variable G_3	Value of possible decisions (Rp)	Value of optimal decisions (Rp)
	G_2 (must be picked)		S_{31}									
	l_{11}	l_{12}	s_{31}	y_{11}	y_{12}	x_{31}	y_{11}	y_{12}	x_{31}	l_{31}		
3	6000	0	7000	6000	0	2000	6000	0	2000	5000	2810619.5 + 1319588 = 4130207.5 *	4,130,207.5
	5000	1000	7000	5000	1000	2000					2810712.5 + 1319588 = 4130300.5	
	4000	2000	7000	4000	2000	2000					2810991.5 + 1319588 = 4130579.5	
	3500	2500	7000	3500	2500	2000					2810852 + 1319588 = 4130440	
	2500	3500	7000	2500	3500	2000					2811177.5 + 1319588 = 4130765.5	
	1500	4500	7000	1500	4500	2000					2811224 + 1319588 = 4130812	
	1000	5000	7000	1000	5000	2000					2811317 +1319588 = 4130905	
	0	6000	7000	0	6000	2000					2811642.5 + 1319588 = 4131230.5	

Tabel 9: The result of picking schedule model for the first 3 days

Name of block	date		
	3	4	5
Wates	1000		
Belendung II	0	6500	6000
Cicenang	7000	2500	
Talaga			2000
demand	8000	9000	8000

Tabel 10: The result of original picking schedule for the first 3 days

Name of block	date		
	3	4	5
Wates	1000		
Belendung II	3500	5000	4000
Cicenang	3500	4000	2000
Talaga			2000
demand	8000	9000	8000

Thus the application of the picking schedule with dynamic programming approach provides a smaller cost (Rp.4,130,207.50**)** than the original picking schedule (Rp.4,140,163.00). Furthermore, for the next scheduling, after the picking results on the 3rd date is known, then the schedule is made for the date of 4th to 6th. And so on until the end of scheduling period.

4. Conclusion

The conclusion on this paper are made as follows:

i. The proposed model of picking schedule gives a better total cost. Although the difference in the value of the rupiahs between the model application and the original picking plan for the first 3 days is relatively small, but if the model is applied for long-term picking scheduling it will result in cost saving.
ii. The application of the model facilitates the achievement of the target quality of the tea buds picked, so that the decreasing quality of tea buds can be minimized. Furthermore, it will affects the quality of the tea products produced, which in turn affects the price and the level of tea sales on the market.

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