ECONOMIC ASPECTS OF THE OPTIMUM REPLACEMENT OF SEEDLING TEA BY HIGHER YIELDING CLONAL VARIETIES[1]

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Abstract

This article concentrates on the optimal replacement of seedling tea by higher yielding clonal varieties. A hypothetical 500ha tea estate under seedling tea is used for this purpose. Representative yields, revenues, costs and replacement data with respect to the hypothetical 500ha tea estate are discussed first. This is followed by a gross margin analysis. However, as this produces only partial answers which may be misleading, a whole farm approach to the replacement problem is subsequently taken. Dynamic linear programming is used to derive economically optimal replacement strategies over a 30 year planning horizon, given certain yield and price scenarios. Some conclusions are also drawn.

Uittreksel
Ekonomiese aspekte van die optimum vervanging van saadtee deur hoër opbrengs kloonvariëteite

Hierdie artikel konsentreer op die optimale vervanging van saadtee deur hoër opbrengs kloonvariëteite. 'n Hipotetiese 500ha teelandgoed word vir dié doel gebruik. Verteenwoordigende opbrengste, inkomstes, kostes en vervangingsdata vir die hipotetiese 500ha teelandgoed is eerstens bespreek. Dit is gevolg deur 'n bruto marge-analise. Omrede dit egter slegs parsiële antwoorde verskaf wat misleidend mag wees, is 'n geheelplaasbenadering tot die vervangingsprobleem vervolgens geneem. Dinamiese lineêre programmering is gebruik om ekonomies optimale vervangingstrategieë oor 'n 30 jaar beplanningshorison te bepaal vir sekere opbrengs- en prysscenario's. Sekere gevolgtrekkings is ook gemaak.

1. Introduction

Intensive agriculture, be it the growing of perennial or annual crops, or a mixture thereof, present many economic problems. There are facets such as combinations and selection of cultivars or varieties, technology, inputs as part of a wider package of financial and asset management, market identification, forecasting and development, and a host of other factors. In a system involving or including perennial crops, such as tea, the replacement decision is narrowly intertwined with the majority of other decisions. Its role can be cause or effect. It can have a profound influence on the profitability of the farm operation. It is for this reason that this article concentrates on the optimal replacement of seedling tea by higher yielding clonal varieties.

Seedling tea is found on several South African tea estates. Although these operations are still financially viable and yield good profits, the question often arises whether profits can be increased by replacing the old seedling tea with higher yielding clonal varieties. However, the answer to this question is not straightforward as many factors have to be taken into account simultaneously. This article will address this question by attempting to determine economically optimal replacement strategies of seedling tea by higher yielding clonal varieties. A hypothetical 500ha tea estate under seedling tea is used for this purpose.

The *modus operandi* will be to examine representative yields, revenues, costs and replacement data with respect to the hypothetical 500ha tea estate first. This will be followed by a gross margin analysis. However, as this produces only partial answers which may be misleading, a whole farm approach to the replacement problem is subsequently taken. Dynamic linear programming is used to derive economically optimal replacement strategies over a 30 year planning horizon, given certain yield and price scenarios. Some conclusions are drawn at the end of the article.

2. Yields, revenues, costs and replacement data

2.1 Introduction

As already mentioned, a hypothetical 500 ha tea estate under mature seedling tea is used to illustrate the problems involved with the replacement decision. Four different combinations of hypothetical clones, each with a different yield potential (low, average, high and ultra high), are considered as alternatives to the existing seedling tea. The infrastructure of the hypothetical estate is taken as given. Facilities with respect to labour, the factory, etc. are adequate, given existing yields. However, higher tea yields due to improved clonal varieties, resulting in an increasing total output of tea, will require additional infrastructure, specifically with respect to processing facilities and housing for labour. Representative data provided by Sapekoe are used to facilitate the analysis.

These aspects are subsequently discussed in more detail in this section. Establishment costs of new clonal tea are discussed first. This is followed by a discussion of yields, plucking labour and variable costs. Fixed costs for the estate were also calculated. Additional costs incurred, depending on total output, are subsequently examined, followed by a brief discussion of the tea prices which concludes this section. Monetary values are expressed in 1990 Rands.

2.2 Establishment costs

Establishment costs consist of several items, namely removal of existing tea plants, repairs to the existing irrigation system which will be damaged during the removal process, soil preparation costs, cost of new clonal plant material and the planting of the tea.

Removal of tea: It was estimated that a bulldozer will take 17 hours to clean and prepare one hectare of seedling tea. Calculated at R230,00 per hour, it means that clearing costs will total **R3 910/ha.**

Table 1: Yield, plucking labour and variable cost projections for the clonal tea used in the seedling replacement exercise (constant 1990 prices)

Year	Clonal tea yield scenarios (kg/ha)*				Plucking labour (Units/ha)**				Variable costs R/ha
	Low	Average	High	Ultra-high	Low	Average	High	Ultra-high	
1	35	80	138	200	24	54	93	135	2075
2	190	300	477	600	65	102	162	204	2540
3	667	900	1406	1600	176	238	354	423	3962
4	1338	1700	1933	2500	180	311	362	457	5166
5	1295	2200	3469	4000	187	317	372	576	5932
6	1400	2500	3600	4500	190	321	476	578	6180
7	1600	2800	4000	5000	203	333	485	595	6317
8	1800	3000	4300	5250	216	339	497	593	6525
9	2000	3200	4600	5500	227	346	500	594	6866
10	2200	3400	5000	5750	245	351	512	594	7203
11	2400	3600	5200	6000	248	372	537	620	7627
12	2600	3800	5400	6250	268	392	557	645	8050
13	2800	4000	5600	6500	289	413	578	671	8474
14	2900	4200	5700	6750	299	433	588	696	8898
15	3000	4400	5800	7000	310	454	598	722	9321
16	3200	4600	6000	7250	330	475	620	749	9745
17	3400	4800	6200	7500	351	495	639	773	10169
18	3700	5000	6300	7750	382	516	650	799	10592
19	4000	5200	6400	8000	413	537	661	826	11015
20	4300	5400	6500	8000	444	557	670	825	11440
:	:	:	:	:	:	:	:	:	:
30	4300	5400	6500	8000	444	557	670	825	11440

* The yield of the existing seedling tea is constant at 3422 kg/ha.

** Plucking labour used by the existing seedling tea is constant at 419 units/ha (labour unit = labour-day).

Irrigation: Two scenarios were put forward with respect to irrigation equipment. Assuming that the main lines will not be damaged in the removal process, repair and replacement costs will amount to **R4 000/ha.** However, if the main lines have to be replaced, total costs will amount to **R8000/ha.**

New plant material: Costs of new plant material were estimated at between **R200/ha** and **R500/ha** depending on the method used (A planting density of 10 800 plants per hectare was assumed).

Planting of tea: The planting cost of tea was calculated at **R615/ha**. This includes the following items: marking of holes; making of holes; and planting.

2.3 Yields, plucking labour and variable costs

The existing mature seedling tea was assumed to yield **3 422 kg** of made tea per hectare. Variable costs (total) amount to **R7 515/ha**, while **419 units** of plucking labour per hectare are required. These figures are based on representative values obtained for the South African tea industry.

Table 1 provides the yield, plucking labour and variable cost projections for the clonal tea used in the seedling replacement exercise. Although these yields are hypothetical, they closely correspond to figures obtained in the Southern African tea industry. Table 1 shows that the clonal tea will have higher yields than the existing seedling tea after 11, 6 and 5 years for the average, high and ultra-high yield scenarios, respectively. Table 1 also shows that the productivity of plucking labour is higher with higher yielding clonal varieties than with seedling tea.

2.4 Fixed costs

Fixed costs for the hypothetical 500ha tea estate used in the replacement exercise was assumed to be **R4 591 689** per annum (1990 prices). This corresponds to results obtained in the South African tea industry. These fixed costs will stay constant if the seedling tea is replaced by clonal tea.

2.5 Additional costs

The higher yields obtained with clonal tea under the average, high and ultra-high yield scenarios will eventually result in a higher total yield for the estate as a whole (Table 1). This implies that additional facilities and infrastructure will have to be provided, especially with respect to processing the tea (factory capacity) and the housing of labour. Apart from the additional infrastructure to cope with higher volumes, extra bins will also be necessary to allow for proper classification of the clonal tea.

Factory: Assuming that clones are planted and that the factory does desiccated processing, additional bins will be needed for each of the following grades for each individual clone: BOP; BOP1; BOP7; BOP71; BM; BM1; PD; PD1; Dust; Dust1; and Waste. Eleven bins per clone planted are thus required. If waste is assumed to be homogeneous among the different clones, then 10 bins will be required for each additional clone. At a price of R5000 per bin, five clones will need an immediate additional initial investment of R255000. Each additional 1000 kg of green leaf tea over and above the existing total capacity will require an additional withering trough at **R13 250**. A processing line consists of two cutting lines, one drier with a burner and three sorting lines. If the present capacity of the factory is exceeded, additional processing lines will be necessary. The various costs are as follows: R500 000 per cutting line; R650 000 per drier with burner; and R200 000 per sorting line. The total costs amount to **R2 250 000** per additional processing line. Such a processing line will be able to handle 3000 kg of green leaf per hour, which will yield roughly 632 kg of made tea.

Village: Labour housing is adequate for existing requirements. Additional labour housing costs at **R60000** per unit will house 40 employees.

2.6 Tea prices

Two scenarios with respect to prices were used. First, real prices received in 1990 were held constant over the planning horizon for all the cases. Second, real prices inside the quota were reduced by 3,5 per cent per annum, while prices outside the quota (world market prices) were held constant. The second scenario is consistent with plans to phase out the protection the local tea industry receives through quotas and controlled prices. Table 2 gives the prices used in the replacement exercise.

Table 2: Real tea prices (cents/kg) used in the replacement excercise (constant 1990 prices).

Year	Inside quota (seed and clonal tea) (c/kg)	Outside quota		
		Seed (c/kg)	Clonal (c/kg)	Waste (c/kg)
1	840	445	525	120
2	811	445	525	120
3	782	445	525	120
4	755	445	525	120
5	728	445	525	120
6	703	445	525	120
7	678	445	525	120
8	655	445	525	120
9	632	445	525	120
10	610	445	525	120
11	588	445	525	120
12	568	445	525	120
13	548	445	525	120
14	529	445	525	120
15	510	445	525	120
16	492	445	525	120
17	475	445	525	120
18	458	445	525	120
19	445	445	525	120
20	445	445	525	120
:	:	:	:	:
30	445	445	525	120

From Table 2 it appears that prices of seedling tea will be the same inside and outside the quota after about 20 years. This is consistent with the policy of phasing out quotas and the reduction of price protection.

The following was assumed with respect to existing quota arrangements: (1) 10 percent of the total yield is waste; (2) the existing quota makes provision for 85 per cent (1 450 000 kg) of the total harvest obtained on the hypothetical estate (1 711 000 kg) to be sold inside the quota.

3. Gross margin analysis: A partial solution

An idea of the complexity of the replacement problem can be obtained by using the above information to derive a partial solution where fixed costs are not considered. Although these solutions obtained by making use of the time value of money (net present value method) do not provide accurate answers, they give an indication of what can be expected on a gross margin per hectare basis. The net present value method is used to derive partial solutions to the replacement problem.

Capital or investment budgeting usually concerns envisaged capital investments in long and medium term assets such as planting orchards, etc. It also contains information such as projects being planned and/or assets to be acquired, estimated investment amounts and investment periods, expected benefits and the duration thereof, and the period during which the project will be completed (Faris, 1960; 1961).

Investment decisions are often more important than, for example, decisions to incur current expenses. In the first place, the effect of present investment decisions will be felt for many years to come. Secondly, investment decisions are largely irrevocable, since there is often no market for second hand capital goods. There are also many conceptual problems involved in investment decisions, such as estimating the investment amount and expected benefits, conflicting results of various financial selection criteria, and the diversity of opinions when determining the returns. Fourthly, the long term nature of investments increases the risk and uncertainty involved. Finally, purchasing a capital asset requires an immediate capital outlay, while the income or benefit from the investment only accrues to farm business over a number of years (Rae, 1977).

Because the benefits which arise from such capital expenses depend on future events and are therefore subject to risks and uncertainties, capital investment decisions and alternatives should be thoroughly analysed before a decision is made. The capital investment problem is based on the underlying time value of money (Faris, 1960). Time value of money lies in the fact that money in possession today (presently) is more valuable than the same amount in the future, regardless of the effect of inflation. This time value is the result of (Winder and Trant, 1961: 939-951) interest on profit which can in the meantime be earned on the money; and the risk involved in only receiving money in the future with its many uncertainties.

Traditionally, capital projects were evaluated according to either priority granting, the observation method, the simple rate of return or the payback period. These methods all have their advantages and disadvantages. However, they all have serious shortcomings especially in respect of the time value of money. As indicated above, money has a certain time value which these methods ignore, and they are therefore not recommended or discussed in relation to capital investment (Chrisholm, 1976; 1986).

Although several other modern financial selection criteria take the time value of money into account when evaluating investment decisions, the **net present value method** in particular carries a lot of merit and has many application possibilities in this regard. The net present value method involves calculating the difference between the sum of the present values of the net cash flows and the sum of the present values of the investments; both being calculated at reasonable required rates of return or discount rates (Barnard and Nix, 1982; Lambrechts *et al*, 1979).

The time value of money, and specifically the net present value method, can be used to choose between different alternative investments when benefits from these investments stretch over several years (Burt, 1965). Given the information in Section 2, this method can be used to:

- calculate net present values for seedling and clonal tea over a planning period of 10, 20 or 30 years; and
- calculate the break even point (years) between existing seedling tea and the proposed clonal tea under varying conditions.

Table 3 provides the net present values of the existing seedling tea and proposed clonal tea on a per hectare basis over planning periods of 10, 20 and 30 years for four different yield and two price scenarios, while Table 4 gives the break-even period between the seedling and clonal tea (in years). Four different real discounting rates were used for the calculations, namely 5%; 7,5%; 10% and 12,5%.

From Tables 3 and 4 it is clear that clonal tea is a better option than seedling tea over a 30 year planning period when:

- High yields are expected and the discount rate is less than 7,5% under a declining price scenario;
- ultra-high yields are expected and the discount rate is less than 12,5% under a declining price scenario;
- high yields are expected and the discount rate is less than 5,0% under a constant price scenario; and
- ultra-high yields are expected and the discount rate is less than 10,0% under a constant price scenario.

Table 3: Net present values of the existing seedling tea and proposed clonal tea over planning periods of 10, 20 and 30 years for four yield and two price scenarios based on gross margin analysis (R/ha).

Planning horizon (years) (years)	Real Discounting rate (%)	Declining price scenario: Existing seedling tea	Clonal tea: Yield scenarios: Low	Average	High	Ultra-high	Constant price scenario: Existing Seedling tea	Clonal tea: Yield scenarios: Low	Average	High	Ultra-high
	5,0	127 049	7 277	43 228	76 534	99 799	157 447	19 672	65 237	98 953	122 699
	7,0	115 885	4 362	35 081	63 588	83 613	141 991	14 728	53 560	82 447	102 912
10	10,0	106 443	1 982	28 390	52 955	70 301	129 001	10 708	43 999	68 916	86 668
	12,5	98 398	29	22 861	44 165	59 282	118 020	7 418	36 121	57 753	73 243
	5,0	165 551	37 141	103 551	170 965	221 701	243 070	87 350	166 690	234 514	285 730
	7,5	143 213	25 092	77 215	129 856	168 886	202 124	61 756	124 466	177 487	216 958
20	10,0	126 074	16 564	59 196	100 044	130 708	171 774	43 806	94 184	136 384	167 453
	12,5	112 660	10 414	44 200	78 022	102 584	148 803	30 995	72 065	106 215	131 150
	5,0	184 761	65 042	147 539	231 040	303 712	295 616	141 837	237 263	321 174	394 326
	7,5	153 879	40 584	101 639	163 212	214 422	231 301	92 009	163 651	225 604	277 255
30	10,0	132 103	25 320	72 001	118 898	156 446	188 265	60 906	11 633	163 582	201 535
	12,5	116 125	15 447	52 136	88 859	117 380	158 283	40 825	84 797	121 848	150 741

Table 4: Break-even period between the existing seedling tea and the proposed clonal tea for four yield and two price scenarios based on gross margin analysis (years).

Discounting rate (%)	Declining price scenario: Low yield	Average yield	High yield	Ultra high	Constant price scenario: Low yield	Average yield	High yield	Ultra high
5,0	*	*	19	14	*	*	23	15
7,5	*	*	25	16	*	*	*	17
10,0	*	*	*	19	*	*	*	22
12,5	*	*	*	29	*	*	*	*

* Break-even period does not occur within a 30 year planning horizon.

In the other cases seedling tea is financially more attractive than clonal tea. This applies to all the situations where yield expectations are low or average. However, the above results are partial in that fixed and additional costs were not taken into account (gross margins were used for the analyses). Given these omissions, partial solutions may lead to incorrect conclusions. The phasing in of clonal tea over time to avoid teething, capacity and cash flow problems to some extent was also not considered. A whole farm approach is thus needed to incorporate these factors and fully evaluate the replacement decision.

4. A whole farm approach to the replacement problem

4.1 Introduction

The replacement problem must be seen holistically and in its proper perspective if meaningful conclusions and correct decisions are to be made. Dynamic linear programming lends itself to such analyses and is a very useful and powerful tool in modelling complex replacement decisions (Conradie, 1990; Hazell and Norton, 1986; Shapiro, 1984).

Dynamic linear programming (DLP) models can overcome many of the limitations of the stationary equilibrium approach to modeling investment decisions. Unfortunately, they typically lead to much larger models and this greatly reduces their practical usefulness. As their name implies, DLP or multiperiod models include two or more periods in which decisions must be made. Usually periods are defined as years, but they can also be based on longer intervals. It is not even necessary that all the periods be of equal length. Activities and constraints are included in each period for all the relevant decisions and many of these will be duplicated from one period to the next (e.g. activities for annual crops). A multiperiod model is more than a sequence of single period models though, because the investment decisions link the periods together. The objective function also provides a link between periods, and typically the discounted sum (or present day value) of profits generated over the entire planning horizon is maximized (Rae, 1977).

4.2 Assumptions and alternatives modelled

The following assumptions, which are additional to those already mentioned in Section 2, apply to the results presented in this section: (1) Two real discounting rates were used in the analyses, namely 5,0% and 10,0% (these relatively high rates are due to the scarciyy of capital and the uncertainties involved over a 30 year planning period); (2) the real interest rate payable on outside capital is 6,0% per annum; (3) the real interest rate on savings is 1,0% per annum; (4) the planning horizon is taken as 30 years to allow for tea planted after 10 years to reach maturity; and (5) the maximum area that can be replaced in a given year is 100 ha.

The existing situation was modelled first to obtain a "benchmark" against which to evaluate the different alternatives. Only some selected results that show the effects of different scenarios on the optimal replacement decision are presented.

Several alternatives were modelled in order to obtain the optimal replacement strategy for the existing seedling tea, namely (1) four yield levels for clonal tea were used, namely low, average, high and ultra-high yields; (2) two price scenarios were taken into account; (3) two real discounting rates were used, namely 5% and 10%; and (4) in addition, establishment and annual fixed costs cost were also varied.

4.3 Results

4.3.1 5% discount rate; declining quota prices; high establishment costs

Table 6 provides the net present value and replacement strategy for the different yield scenarios described above, given a 5% discount rate, declining quota prices and high establishment costs.

Table 6: Net present value and replacement strategy for the different yield scenarios over a 30 year planning period (discounting rate is 5%; quota prices decline over time and establishment costs are high).

Item	Yield scenarios			
	Low	Average	High	Ultra-high
NPV over 30 years (R million)	*	3,408	21,642	46,175
Replacement (ha):	None			
Year 1		29,2	81,5	100,0
Year 2		0,7		87,5
Year 3		31,3	100,0	14,4
Year 4		100,0	100,0	
Year 5				75,4
Year 6			1,9	47,5
Year 7			13,7	65,2
Year 8				55,9
Year 9			76,3	54,1
Year 10				
Year 11			100,0	
Year 12			26,6	
Year 13				
Year 14				
Total		162,2	500,0	500,0
Additional factory capacity (year)	None	Year 13	Year 13	Years 11 and 20

* Infeasible solution

From Table 6 the following can be deduced: (1) The low yield scenario provides an infeasible solution because yields and prices are too low to render the estate viable over the total planning period; (2) some replacement of seedling tea occurs with the average yield scenario: 162,2 ha of clonal tea is planted over the first 4 years; (3) all 500 ha of seedling tea is replaced by clonal tea with the high yield scenario. This is spread out over a period of 12 years; and (4) and 500ha of seedling tea is replaced with clonal tea in the first nine years with the ultra-high yield scenario.

4.3.2 5% discount rate; constant quota prices; high establishment costs

Table 7 provides the net present value and replacement strategy for the different yield scenarios described above, given a 5% discount rate, constant quota prices and high establishment costs. The following observations can be made from Table 7: (1) No replacement takes place in the low and average yield scenarios; (2) 500 ha of seedling tea is replaced by clonal tea under the high yield scenario in the first 12 years; (3) 500 ha of seedling tea is replaced by clonal tea under the ultra-high yield scenario in the first 9 years.

4.3.3 5% discount rate; declining quota prices; low establishment costs

Table 8 provides the net present value and replacement strategy for the different yield scenarios described above, given a 5% discount rate, declining quota prices and low establishment costs (R6 000/ha instead of R10 000/ha).

Table 7: Net present value and replacement strategy for the different yield scenarios over a 30 year planning period (discounting rate is 5%; quota prices are constant over time and establishment costs are high).

Item	Yield scenarios			
	Low	Average	High	Ultra-high
NPV over 30 years (R million)	58,187	58,187	66,821	91,699
Replacement (ha):	None	None		
Year 1			100,0	100,0
Year 2			85,7	97,4
Year 3			24,0	27,8
Year 4			34,3	39,6
Year 5			23,3	56,3
Year 6				84,8
Year 7			22,6	65,9
Year 8			40,8	
Year 9			35,7	28,2
Year 10			38,7	
Year 11			44,5	
Year 12			40,4	
Year 13				
Year 14				
Total	0,0	0,0	500,0	500,0
Additional factory capacity (year)	None	None	Year 14	Years 10 and 19

According to Table 8 the replacement pattern is as follows: (1) The low yield scenario provides an infeasible solution because yields and prices are too low to render the estate viable over the total planning period; (2) some replacement of seedling tea with the average yield scenario: 168,6 ha of clonal tea is planted over the first 4 years; (3) all 500 ha of seedling tea is replaced by clonal tea with the high yield scenario. This is spread out over a period of 8 years; and (4) all 500ha of seedling tea is replaced with clonal tea in the first 8 years with the ultra-high yield scenario.

4.3.4 10% discount rate; declining quota prices; high establishment costs

Table 9 provides the net present value and replacement strategy for the different yield scenarios described above, given a 10% discount rate, declining quota prices and high establishment costs. From Table 9 it appears that: (1) the low yield scenario gives an infeasible solution due to low yields and prices which render the estate non-viable; (2) 148,7ha seedling tea is replaced by clonal tea under the average yield scenario. Replacement takes place within the first three years; (3) 500 hectares seedling tea is replaced by clonal tea in the first 12 and 9 years under the high and ultra-high yield scenarios, respectively.

Table 8: Net present value and recement strategy for the different yield scenarios over a 30 year planning period (discounting rate is 5%; quota prices decline over time; low establishment costs: R6000/ha).

Item	Yield scenarios			
	Low	Average	High	Ultra-high
NPV over 30 years (R million)	*	3,994	23,787	48,064
Replacement (ha):	None			
Year 1		29,2	96,7	100,0
Year 2		0,7	100,0	100,0
Year 3		1,9	100,0	11,1
Year 4		100,0	3,8	81,5
Year 5		36,8	18,1	55,0
Year 6			24,3	76,6
Year 7			100,0	59,4
Year 8			57,1	19,4
Total		168,6	500,0	500,0
Additional factory capacity (year)	None	Year 13	Year 13	Years 10 and 19

* Infeasible solution

Table 9: Net present value and replacement strategy for the different yield scenarios over a 30 year planning period (discounting rate is 10%; quota prices decline over time and establishment costs are high).

Item	Yield scenarios			
	Low	Average	High	Ultra-high
NPV over 30 years (R million)	*	4,182	23,302	48,552
Replacement (ha):	None			
Year 1		29,2	81,5	100,0
Year 2		29,8		87,5
Year 3		89,8	100,0	14,4
Year 4			100,0	
Year 5				75,4
Year 6			1,9	47,5
Year 7			13,7	65,2
Year 8				55,9
Year 9			43,7	54,1
Year 10			47,5	
Year 11			100,0	
Year 12			11,7	
Total		148,7	500,00	500,00
Additional factory capacity (year)	None	Year 14	Year 13	Years 11 and 20

* Infeasible solution

5. Conclusions

Results obtained from the different analyses show that the replacement problem must be seen holistically and in its proper perspective if meaningful conclusions and correct decisions are to be made. Dynamic linear programming lends itself to such analyses and is a very useful and powerful tool in modelling complex replacement decisions.

Yield and price scenarios play important roles in the replacement decision, while the effects of discount rate and establishment costs are less important with respect to the ranges for these variables used in this analysis. This leads to the following generalizations:

Given a declining price of quota tea scenario the following principles apply:

- The existing seedling yield ratios are insufficient to counter the negative effects of the lower prices with the result that the operation becomes non-viable;
- Clonal tea under the low yield scenario does not provide a sufficiently higher income to make the operation viable;
- Clonal tea under the average, high and ultra-high scenarios renders the operation viable where seedling tea is replaced by clonal tea.
- Roughly 150 ha of seedling tea is replaced by clonal tea in the first three to four years under the average yield scenario; it thus seems that benefits from further replacement are not large enough to justify additional capital expenditures.
- All 500 ha of seedling tea is replaced by clonal varieties over a period of roughly 10 years under the high and ultra-high yield scenarios. These scenarios result in substantial increases in the profitability of the operation, respectively in the order of 5 times and 10 times above that obtained under the average yield scenario.

Under a constant price scenario which maintains the status in the tea industry, the following principles apply:

- Replacement does not take place under the low and average yield scenarios because the yield effect alone is not enough to make replacement viable relative to maintaining the status quo.
- All 500 ha of seedling tea is replaced by clonal varieties over a period of roughly 10 years under the high and ultra-high yield scenarios. Results are thus similar to that achieved with declining prices.
- Constant prices result in substantially higher net present values as against the situation with declining quota prices for tea.

These results and generalizations should be evaluated against the assumptions, general nature and shortcomings of the model and approach used. However, the results illustrate the complexity of the replacement problem. It also provides answers which are useful in evaluating the replacement problem in its proper context. Given specific details and information with repect to a particular estate, dynamic linear programming can provide useable strategies and answers which conform to management's objectives.

Notes

1. Based on a MSc (Agric) dissertation by PJ Botha at the University of Pretoria.
2. Mr Botha is currently employed by the Department of Agricultural Development.

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