DECISION TREE MODELLING TO SUPPORT INVESTMENT DECISIONS ON FLOWER PRODUCTION FOR THE NORTHERN HEMISPHERE

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The aim of this research was to develop a generic decision tree model that captures and integrates in a logical and orderly manner the impacts of production and marketing activities that determine the profitability of flower production for export. The model has to indicate options necessitating choices between alternative production and marketing activities and has to show the impact of a particular choice on the profitability of the total operation. The model should be easily adaptable to evaluate the suitability of various flowers for export. The model was applied to describe the income and cost determinants and relevant choices with regard to the production of Protea Magnifica (Queen Protea) in the Western Cape to be sold on Dutch flower auctions.

1. INTRODUCTION

The production of flowers in South Africa for the northern hemisphere flower markets can be increased considerably (Kaiser Associates, 2000). In the case of indigenous fynbos products, South Africa has a treasure of indigenous flower material that can be used to expand the range of flowers for export in order to increase the flexibility of the industry in the face of possible sudden shifts in consumer demand. Furthermore, South Africa has a good infrastructure to export flowers, with a proper road network and international airports. With appropriate focus and investment, the South African floriculture industry has the opportunity to create over 80000 new jobs and to earn $250m in foreign exchange over the next ten years (Kaiser Associates, 2000). Various factors favour such export oriented flower production for the northern hemisphere markets. South African producers benefit from seasonal differences in the case of flowers commonly grown in the northern hemisphere. Further factors include the increasing costs of northern hemisphere production, primarily due to rising heating costs and environmental protection measures, rising consumer demand for exotic flowers and a greater variety available year-round, as well as the weakening SA Rand versus northern hemisphere currencies.

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A wide variety of determinants of the profitability of flower production in the southern hemisphere for northern hemisphere markets have to be considered to determine whether export production of a particular flower is technically and financially viable. The impact of possible changes in the determinants showing the vulnerability of such an export production operation must be determined in order to plan preventative strategies. The more critical determinants also provide specifications for breeding programmes to create flowers with more desirable characteristics for export production.

The aim of this research project was to develop a generic decision tree model that captures and integrates in a logical and ordinary manner the impacts of a variety of production and marketing activities determining the profitability of flower production for export. The model has to indicate options necessitating choices between alternative production and marketing activities and has to show the impact of a particular choice on the profitability of the total operation. The model should be easily adaptable in order to evaluate the suitability of various flowers for production for export. The model was applied as an *ex post* case study, to describe the income and cost determinants and relevant choices with regard to the production of *Protea Magnifica* in the Western Cape for export to be sold on Dutch flower auctions.

2. DECISION TREES

The suitability of a decision tree as a tool to evaluate a strategy lies in its ability to order activities and choices within the process in a logical, rather straightforward manner. The decision tree can facilitate choosing between alternative activities. It is therefore seen as the appropriate tool for structuring the evaluation model.

The basic decision tree is composed of four elements: branches, decision nodes, event nodes and outcomes (payoffs). A *branch* is a single strategy or event possibility that connects either two nodes or a node and an outcome. A *decision node* is a point on the tree represented by a square, from which two or more branches emerge. Each branch from a decision node will thus represent a possible single action to be taken by the decision maker. An *event node* is a point on the tree represented by a circle, from which two or more branches emerge. Each of these branches will represent a possible event that might take place. Actions are at the discretion of the decision maker, while events are not. The *outcomes* are the results (payoffs) of strategies consisting of a sequence of actions and events that form a unique path in the tree from the initial point to the end point Gordon (1978).

3. APPLICATIONS OF DECISION MAKING THEORY IN AGRICULTURE

Application of decision making theory in agriculture and horticulture is fairly common, e.g. to improve farm profitability (Henry, 1999), to maximise milk yields (Sugimoto & Nibe, 1999) and crop production (Li et al., 1999, Audsley et al., 1997, Gary et al., 1998). Another area where decision making theory is repeatedly used is precision agriculture, which includes general decision making (Michael & Withers, 1998) and the use of different tools like GPS and yield mapping to assist in the process of decision making (Fleming et al., 1999, Zhang et al., 1999, Larscheid, 1997). Other applications include the control of pests and diseases (Fabre et al., 1999, Huang et al., 1999, Syobu et al., 1999) and women's decision making (Kishor et al., 1999, Sirisena et al., 1999, Reddy et al., 1997).

Decision trees are often used in research to include uncertainty with regard to extension work (Compton, 1997), tourism patterns (Tichler et al., 1999), herbicide application (Frederickson et al., 1998), farmer decisions (Darnhofer, 1997, Fairweather, 1996) and crop production (Wale et al., 1998). The last three applications of decision trees are particularly relevant to this study. General quality of agricultural and horticultural products (Kennet et al., 1998, Mora *et al*, 1997), food safety (Hooker et al., 1999, Henson & Northen, 1998) and certification (Buck et al., 1997) are just a few examples of research on quality in the supply chain. Decision trees have also been used to assess the economic and strategic issues surrounding the introduction of genetically modified wheat, soybeans, maize and canola (PG Economics Ltd, 1999) to the food chain. Another application assesses the costs and returns of the forest product 'Capillobia' in Nigeria (Abang & Ideba, 1998). Similar research has been performed on Swedish forestry products (Johansson, 1995), analysing the cost of raw material at the timber mill and upstream to the forest. This reversed chain approach seems useful for structuring the model for flowers in order to promote market focused production. Finally, a benchmark study on the Australian apple industry (Australian Apple and Pear Grower's Association, 1996) provides information on aspects of apple production. The incorporation of cost, yield, quality, chemical use, technical support, packing costs, freight and packaging costs considerations provided useful guidelines for the construction of the flower production decision tree.

4. CASE STUDY: EVALUATING *PROTEA MAGNIFICA*

An *ex post* evaluation of *Protea Magnifica* as the main export protea of the South African fynbos industry sold on Dutch flower auctions was done to illustrate the use of the flower decision tree model. *Protea Magnifica* (commonly known as the Queen Protea) is a member of the Protea family and was formerly known as *Protea Barbigera*.

4.1 Data sources

Production and cost data for the case study were obtained mainly from a survey among protea producers conducted in 1997 by the Fynbos Research Unit of the Institute for Vegetables and Ornamental Plants of the Agricultural Research Council of South Africa and inflated to 2000 values. The survey covered 88 producers of Proteaceae products in the different regions of South Africa. The Federation of Dutch Flower Auctions (VBN) supplied data on average prices on the Dutch flower auctions. The cost of transport between South Africa and The Netherlands was obtained from airfreight agents in Cape Town. Cape Town was chosen as the airport or seaport of departure, because it is the nearest to the main *Protea Magnifica* producing areas in the Western Cape.

A multidisciplinary expert group, consisting of a horticulturalist[3], a plant pathologist[4], an entomologist[5], a plant breeder[6] and an agricultural economist[7], all specialising in various aspects of fynbos production, provided information for most of the technical parameters. The expert group evaluated the technical viability of alternative production and transport activities and determined probabilities of damage from pests and diseases in the case of chemical control or non-control under various climatic conditions. The estimation of such probabilities can only be based on sharing of experience of the experts and consensus amongst them, due to the absence of time series data (cf. Conradie, 1995).

4.2 Assumptions of the model

Some assumptions had to be made in order to derive certain costs:

- An average size of three hectares for a protea farm was assumed in calculating depreciation;
- An exchange rate of R6,69 per Euro was assumed;

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- It was assumed that the investments take place with equity capital and that all the financial risk is borne by the investor. This also implies that interest is excluded from the model.

4.3 Structuring of the model

The decision tree starts with market activities, moving towards production activities to emphasise the importance of effective market research to direct production decisions. Each path in the decision tree represents a feasible strategy consisting of a unique set of activities resulting from particular choices between alternative activities. Infeasible strategies are not mapped. The decision tree ends with the profitability outcomes of the alternative strategies. The decision tree model for the case study contains only decision nodes indicating choices to be made between alternative actions, and no event nodes (see Figure 1). In order to apply the model for other flowers, the structure of the model, as well as the values of the parameters, have to be adapted to fit the characteristics of the flower, e.g. the option of transport of cut roses by sea will not exist.

The income or cost implications of the actions, combined with further marketing and production costs not resulting in alternative actions or events, were incorporated in a spreadsheet model. The spreadsheet model allows rapid calculation of the complete financial outcome of each strategy, as well as the impact of changes in income or cost determinants via sensitivity analyses.

5. THE CRITERIA AND PARAMETERS OF THE MODEL

5.1 Model criteria

Various criteria are used to evaluate alternative strategies consisting of different marketing and production activities. An activity involves an income or a cost. A criterion can be seen as a function indicating a direction of increasing or decreasing preferences (Beroggi, 1999). In this study, three broad criteria were used for evaluation:

- *The market criterion* is used to determine which set of marketing activities will result in the highest market outcome, which must only be seen as an intermediate income. The market outcome is expressed as the farm gate income per hectare.

- *The production criterion* is calculated as the farm gate income minus the cost of land minus the cost of pest and disease control, reflecting the impact of the relative suitability of the land resources selected for the production of the flowers.

- *The profitability criterion* incorporates further fixed and variable production costs and focuses on the financial outcome of the total system, including the marketing and production activities.

5.2 Model parameters

5.2.1 Market parameters

The market parameters describe the income and cost involving activities from the selling of the flowers on the Dutch flower auctions back to the farm gate. These activities include:

Selling on the auction
The decision tree starts with a decision node indicating a choice between various selling periods. For certain weeks prices tend to be higher because of demand factors e.g. feasts such as Christmas, Valentine's Day, *Allerheiligen* in Germany (especially important for *Protea Magnifica*) and/or because of supply factors, such as short supply when most producers are unable to supply. For *Protea Magnifica* the expert group identified four higher price periods when South African producers are able to supply the market (refer to Table 1). Sales data from 1996 to 1999 were used to calculate average prices per selling period.

Table 1: Average price per *Protea Magnifica* stem for four selling periods

Week	Average prices over 1996 – 1999	Import tariff (%)
Week 33 – Week 38	R10,14	18
Week 39 – Week 41	R13,53	18
Week 42 – Week 44	R15,97	14 (average)
Week 45 – Week 52	R14,50	12,7

Stem length
Stem length is an important price determinant for some flowers. The model should thus allow for a choice among various stem lengths, as a trade-off exists between a higher price for a longer stem and the higher weight and thus higher transport cost of a longer stem. However, available auction statistics for *Protea Magnifica* do not allow differentiation into various length classes, thus only one standard stem length was used.
Quality determined at the auction

The quality is evaluated by inspection at the auctions based on the presence of inferior quality flowers. When the percentage of inferior quality flowers exceeds a certain level, the inspector downgrades the flowers to an appropriate quality class. As in the case of stem length, the auction statistics did not allow for differentiation in terms of quality classes.

Commission at the auctions
The commissions payable at the auctions in the Netherlands differ slightly. For this case study, the commissions of the largest flower auction, at Aalsmeer, were taken. There is a variable commission of 5,2% of the gross income (VBA, 2001) and a rental fee for the crates and lorries. This rental fee is approximately R0,13 per stem.

Transport and handling in Europe
The average cost charged by a few large transport companies in the Netherlands to transport flowers from the airport to the agent and from the agent to the auctions is around R1,25 per stem. The agent sorts the flowers in terms of quality, puts them in fresh water and, if necessary, picks up the low quality flowers from the buyer if he/she has complaints. A fee of 12 percent of the net auction prices (gross income minus auction fees) (Expert group, 2000) is paid for these activities to the agent in The Netherlands.

Import tariffs
Import duties have to be paid when the flowers arrive in the European Union. The import tariff is 18 percent of the value of a consignment during the European summer (1 June to 30 October) and 12,7 percent during the European winter (1 November to 31 May) (refer to Table 1). The custom officer's estimates of the value of the consignment are highly flexible and, in most circumstances, they seem to be lower than the actual value. A value of 65 percent of the gross income on the Dutch auctions was used for determining the import tariff on *Protea Magnifica*.

Transport to northern hemisphere markets
A choice has to be made between the use of airfreight or sea freight for exporting the flowers to Europe. Recent experimentation with refrigerated container transport has showed that it is technically viable for proteas and other fynbos products. Transport by ship implies an unbroken cold chain from the farm to the agent in Europe resulting in good quality, despite the longer period in transit. Sea freight costs only a third of airfreight. Another advantage of sea freight is the availability of cargo space from South Africa to Europe from October to January, the peak marketing season for flowers from the southern hemisphere. During this period, air cargo agents prefer to send

fresh fruit by air, as fruit has a more favourable value/volume ratio than flowers, with the result that cargo space is often unavailable for flower producers (cf. Allerts *et al*, 1998).

The airfreight cost structure is shown in Table 2. The cost of airfreight per kg depends on the total weight of the consignment that will be transported. Larger consignments are clearly more economical than smaller consignments. Consignments larger than 500 kg were assumed for the case study. With an average weight of 300 grams a *Protea Magnifica* stem, the average cost of airfreight for consignments larger than 500 kg would be R3,73 per stem. Sea freight was calculated as R1,24 per stem.

Table 2: Price of airfreight from Cape Town International Airport to Schiphol Airport

Weight range of the consignment	100kg–250kg	250kg–500kg	>500kg
Price per kilogram (R/kg)	15,58	13,18	12,42
Average costs per stem of Protea Magnifica (300 grams per stem) (R)	4,67	3,95	3,73

Source: JJ's Airfreight, 2000.

Transport in the region

In this model, it is assumed that the transport of flowers from the farm to the airport/seaport is done on contract by a transport company to avoid high investment in trucks and trailers. The flowers will be transported in a refrigerated truck to preserve the quality of the flowers. For the *Protea Magnifica* case study, the main growing area is within 200km from Cape Town International Airport. Prices of refrigerated transport over 200km average R165 per pallet. Approximately twenty-four cartons can be stacked on a pallet, each containing thirty flowers (Expert group, 2000). Thus the average price of transport per stem from the farm to the airport or to the seaport was calculated as R0,23 per stem.

5.2.2 Production parameters

The parameters of the production criterion show the impact of (un)suitable physical-biological conditions in terms of stems lost if these conditions are controlled or not controlled, as well as the costs of control activities. Specific quantitative data about the impact of unfavourable soils, climate and pest and disease conditions on the yield of flowers is non-existent, therefore estimates of the multidisciplinary group of experts had to be used.

Under ideal climate and soil conditions, one hectare of *Protea Magnifica* produces on average 26 000 stems per annum over a life span of twelve years of an orchard. The average yield per annum minus stems lost due to unfavourable physical-biological conditions was multiplied by the farm gate price to determine the farm gate income as a starting point for the production criterion. The costs of farm land and the costs of control of pests and diseases were deducted from the farm gate income per hectare. The expert group determined the loss factors.

The impact of climate

The climate parameter incorporates the impact of the (relative) suitability of temperature and light conditions as these were reported to be key growth factors for certain kinds of flowers such as *Impatiens* (Erwin, 1995) and *Chrysanthemum* (Persson & Larsen, 1998). Rainfall is less important than temperature and daylight, because it is much easier to simulate this factor using irrigation. However, certain kind of plants can be severely damaged by high levels of rainfall. This will lead to saturation of the soil with water, causing a deficiency of oxygen (Foth, 1990). The expert group estimated loss factors of three relevant climate conditions for *Protea Magnifica* (see Table 3).

Table 3: Climate conditions of varying suitability for Protea Magnifica

Suitability	Climate conditions	Percentage stem loss
High	Cool Dry High altitude No hoarfrost damage	0
Medium	Cool Dry High altitude Presence of hoarfrost damage	10
Low	Relative higher humidity	50

Soil quality

The soil quality parameter incorporates the impact of the suitability of the soil on the size of the exportable crop (Foth, 1990). *Protea Magnifica* is cultivated in a relatively small area surrounding Piketberg. Its ideal growing conditions are high altitudes and mild summer temperatures, cold winters and sandy soils. Under these conditions, the plant starts growing after the cold winter to produce most of its flowers around November and December, when prices of the flowers are high. If the flower is grown at lower altitudes, the plant starts flowering around July and August when the prices of the flowers are low (Expert group, 2000). The expert group estimated loss factors of three relevant soil conditions (see Table 4). One prerequisite must be met for all three conditions, namely that the soil must be well drained.

Table 4: Soil conditions of varying suitability for *Protea Magnifica*

Soil conditions	Cost of land per hectare (R)	Percentage stem loss (%)
The Piketberg area and surroundings 80% sand, 10% clay, Sand layer deeper than one meter Well drained, low acidity, low in phosphate	6 500	0
The Ceres area 60% sand, 25% - 30% silt, Sand layer one meter deep or less Well drained, low acidity, low in phosphate	1 560	25
Stellenbosch and surroundings High percentages of clay	845	50

The impact of pests and diseases

The impact of pest and diseases is often neglected in an evaluation of a flower project, even though it can have a significant effect on the yield and profitability of the crop. The pest parameter incorporates the potential impact of pests on the size and quality of the flower crop. A pest is classified as an insect that causes sufficient damage to a crop to reduce the yield and/or quality by an amount that is unacceptable to the farmer (Dent, 1991). Fungi, bacteria or viruses cause diseases.

The expert group contributed the following with regard to the potential impact of pests and diseases on the yield of *Protea Magnifica*:

- The identification of the relevant pests and diseases that occur in *Protea Magnifica*;
- The estimation of the maximum yield of flowers per plant without loss due to pests and diseases;
- The estimation of the probability of occurrence of each specific pest or disease;
- The estimation of the loss of yield caused by each specific pest or disease when control measures are taken or not taken; and
- The estimation of the costs of controlling the different types of pests and diseases.

Four groups of pests and two diseases were identified that are relevant to the production of *Protea Magnifica* (see Table 5).

Table 5: Probability and extent of damage of relevant pests and diseases

	Cost of control (R)	Probability (%)	Percentage stem loss with control (%)	Percentage stem loss without control (%)
Pests				
Borers	200	100	5	20
Leaf miners	1 000	100	5	90
Sap suckers	1 000	50	0	50
Leaf eaters	1 000	20	5	50
Diseases				
Cankers	3 000	100	5	50
Leaf spots	3 000	50	10	90

5.2.3 Profitability parameters

The profitability criterion is the last criterion of the decision tree. The profitability criterion is designed as a straight line, subtracting the different costs from the farm income corrected for the potential impact of unfavourable production conditions. All revenues and costs are expressed per hectare.

Plant material

The cost of plant material is determined by the type of flower and can vary considerably between e.g. bulbs, cuttings and seeds. Seedlings are used in the case of *Protea Magnifica*. To determine the cost of plant material, the purchase of plant material was regarded as an investment that will generate cash inflows over the lifespan of the orchard. From this point of view the cost of plant material is calculated in a manner similar to the calculation of the cost of depreciation. At R0,50 for a single seedling and an average plant population of 6000 plants per hectare (Expert group, 2000), the total investment in plant material is R3 000. With an estimated lifespan of an orchard of twelve years, the cost of plant material is R250 per hectare per year.

Cost of labour

The labour cost of production activities in the orchard as well as picking and packing is estimated at R0,50 per stem. (Expert group, 2000).

Costs of chemicals

The chemicals that are used in growing *Protea Magnifica* consist mainly of pesticides, fungicides and herbicides. The pesticides and fungicides are already accounted for in the pests and diseases section. Only the cost of herbicides, at R4000 per hectare per year, is therefore accounted for under the profitability criterion (Expert group, 2000).

Costs of fertilizers

According to the ARC survey the most commonly used fertilisers in the production of proteas include ammonium sulphate, urea and potassium. The total cost of fertilisers for the case study is estimated at R300 per hectare per annum.

Irrigation

The average cost of irrigation other than depreciation of the irrigation network was estimated in the Fynbos survey at R852 per hectare.

Cost of materials

The average cost of a carton is R10 and thirty flowers are packed per carton (Expert group, 2000). Other materials used on the farm are petrol, oil, electricity (cool storage) and water. The cost of these materials is estimated at approximately R14000 per hectare per year.

Depreciation

Standard straight-line depreciation of 5 percent per annum on buildings, 10 percent on cool rooms and 20 percent on farm equipment was taken (see Table 6). An average area of three hectares under proteas per farm was assumed, based on the ARC survey results.

Table 6: Depreciation on farm equipment and buildings

Type of equipment	Buying price (R)	Depreciation rate (%)	Annual depreciation (R)
Tractor	25 000	20	5 000
Plough	4 000	20	800
Sprayer	8 000	20	1 600
Air-conditioning, packing shed and office (per ha)	30 000	5	1 500
Cool room (per ha)	15 000	10	1 500
Irrigation network (per ha)	4 000	10	400
Land preparation (per ha)	10 000	15	1 500
Total depreciation (p.a. per ha)			7 367

Note: An average of three hectares under proteas was assumed.

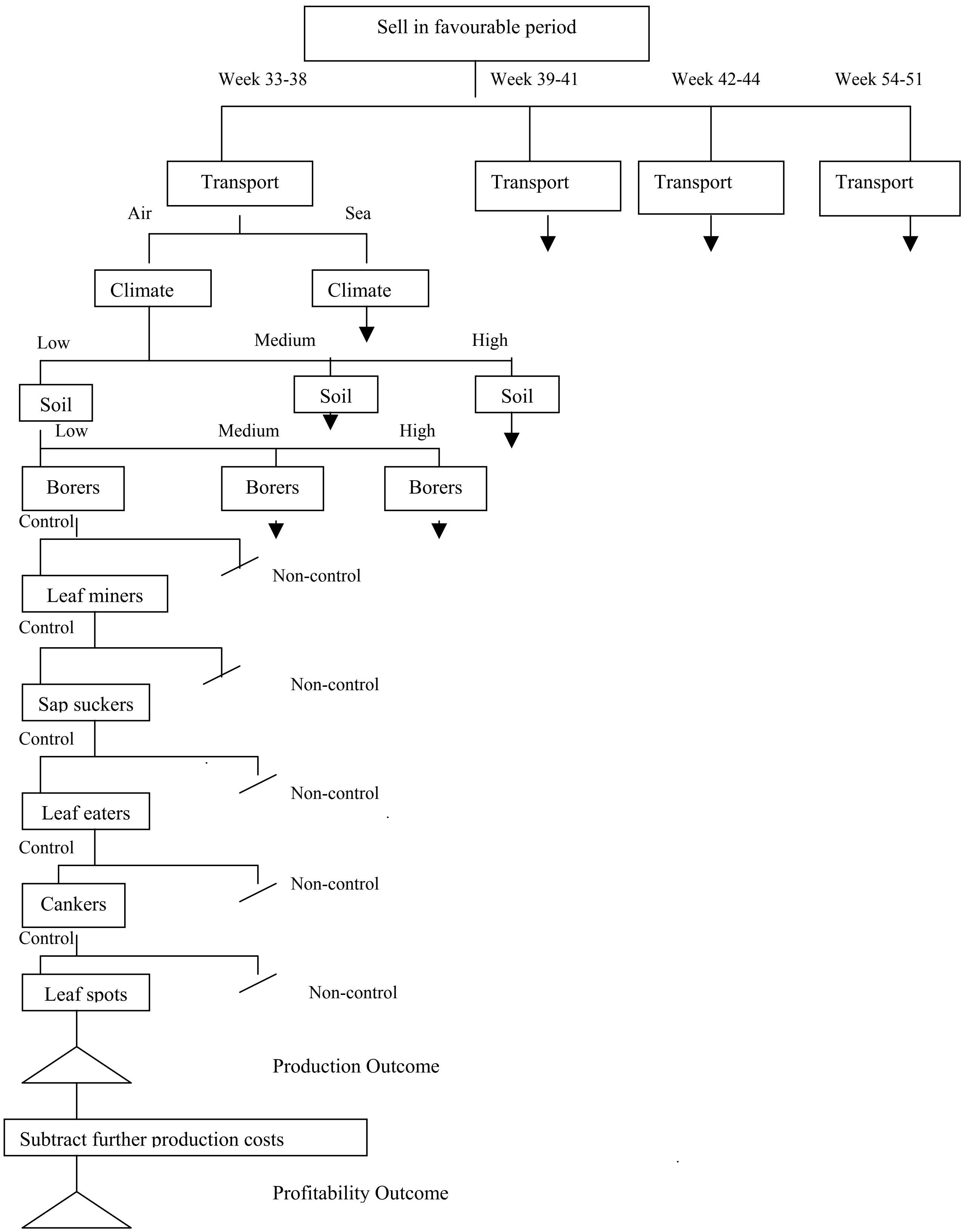
6. RESULTS

The various paths of the decision tree for *Protea Magnifica* are shown in Figure 1 and the financial outcomes of the various strategies (represented by paths) are shown in Table 7. All the outcomes are based on the control of all the relevant pests and diseases as discussed above. Chemical control of pests and diseases is currently the most efficient strategy to meet the strict quality control at the auctions. Fear of resistance by pests and diseases to pesticides, fungicides etc. and the probable growing need to assure buyers of environment-friendly flower production may, however, lead to reduced use of such chemicals. The potential impact of such a strategy can then be ascertained by means of the decision tree model.

The difference in auction incomes within any of the selling periods shows the impact of especially unfavourable climate and soil conditions on the number of marketable stems. Differences between auction incomes resulting from the same production conditions, but in different selling periods, reflect the importance of selling in the best selling periods. Differences between market or profit outcomes from flowers transported by sea and air in the same selling period under the same production conditions show the great impact of savings using transport by sea. All differences between auction income and the corresponding market outcome (farm gate income) show the relatively large share of income absorbed by transport cost, even more so in the case of airfreight.

Auction income and profit outcome ranges from a maximum of R334 816/ha and R133 285/ha respectively for *Protea Magnifica* sold in the best selling period and produced under the most favourable climate and soil conditions, transported by ship to Europe, to R53 147 and –R27 169 respectively for the much lower number of stems per hectare due to unfavourable production conditions, transported by air and sold during the lowest price selling period.

Figure 1: Decision tree for production of *Protea Magnifica* for export to Dutch flower auction



Note: Any downward pointing arrow represents a duplication of that part of the decision tree on the left hand side, from the same level downwards.

Table 7: Financial outcomes of various combinations of activities (R/ha)

Price/stem/ Selected weeks	Model output	SEA									AIR								
		Climate High			Climate Medium			Climate Low			Climate High			Climate Medium			Climate Low		
		Soil H	Soil M	Soil L	Soil H	Soil M	Soil L	Soil H	Soil M	Soil L	Soil H	Soil M	Soil L	Soil H	Soil M	Soil L	Soil H	Soil M	Soil L
W 33-38 R10,14/ stem	Auction Income	212588	159441	106294	191329	143497	95664	106294	79720	53147	212588	159441	106294	191329	143497	95664	106294	79720	53147
	Market Outcome	93053	69790	46527	83748	62811	41874	46527	34895	23263	40849	30637	20425	36764	27573	18382	20425	15318	10212
	Prod Outcome	77353	59030	36482	68048	52051	31829	30827	24135	13218	25149	19877	10380	21064	16813	8337	4725	4558	167
	Profit Outcome	36913	22957	4777	29355	17289	998	-878	-5386	-14119	-15291	-16195	-21325	-17629	-17949	-22494	-26980	-24962	-27169
W 39-41 R13,53/ stem	Auction Income	283661	212745	141830	255295	191471	127647	141830	106372	70915	283661	212745	141830	255195	191471	127647	141830	106372	70915
	Market Outcome	144029	108022	72015	129626	97220	64813	72015	54011	36007	91825	68869	45913	82643	61982	41321	45913	34435	22956
	Prod Outcome	128329	97262	61970	113926	86460	54768	56315	43251	25962	76125	58109	35868	66943	51222	31276	30213	23675	12911
	Profit Outcome	87889	61190	30265	75233	51698	23937	24610	13730	-1374	35685	22037	4163	28250	16460	445	-1492	-5846	-14425
W 42-44 R15,97/ stem	Auction Income	334816	251112	167408	301335	226001	150667	167408	125556	83703	334816	251112	167408	301335	226001	150667	167408	125556	83703
	Market Outcome	189425	142069	94713	170483	127862	85241	94713	71034	47356	137221	102916	68611	123499	92624	61750	68611	51458	34305
	Prod Outcome	173725	131309	84668	154783	117102	75196	79013	60274	37311	121521	92156	58566	107799	81864	51705	52911	40698	24260
	Profit Outcome	133285	95237	52963	116090	82340	44365	47308	30754	9975	81081	56084	26861	69106	47102	20874	21206	11177	-3076
W 45-52 R14,50/ stem	Auction Income	303997	227998	151998	273597	205198	136798	151998	113998	75999	303997	227998	151998	273597	205198	136798	151998	113998	75999
	Market Outcome	169088	126816	84544	152179	114134	76090	84544	63408	42272	116884	87663	58442	105196	78897	52598	58442	43832	29221
	Prod Outcome	153388	116056	74499	136479	103374	66045	68844	52648	32227	101184	76903	48397	89496	68137	42553	42742	33072	19176
	Profit Outcome	112948	79984	42794	97786	68612	35214	37139	23127	4890	60744	40831	16693	50803	33375	11722	11038	3551	-8161

7. CONCLUSIONS

Decision tree modelling proves to be a useful tool to organise the income and cost determinants of flower production for export, to indicate the critical choices and the impact of any choice at any stage on the final outcome in order to select the best options. Such a model can be used for *a priori* evaluation and strategy formulation of new projects (e.g. by investors considering a new venture or plant breeders developing new varieties) or of strategy changes in existing projects (e.g. new production area or mode of transport as new paths in the structure). Furthermore, the model is useful in showing the impact of external factors (e.g. transport cost or import tariffs) that may cause certain strategies to become unprofitable.

An expert group proved to be a valuable source of information in identifying production activities, relevant choices and probabilities of occurrence of various results of the choices. Depending on the flower in focus, such an expert team can consist of specialists from both the northern and southern hemisphere.

The application of the model to *Protea Magnifica* shows the critical determinants. Important principles for profitable production of flowers for export to the northern hemisphere can generally be derived from these results.

The results show that the *time of selling* is an important determinant. It is far more profitable to sell in Week 42 to 52 than in other periods. Generally, flower varieties should be selected and/or developed for the southern hemisphere to exploit the advantage of seasonal differences maximally when the northern hemisphere producers cannot satisfy consumer demand, or only at higher cost due to heating. A favourable harvest time from a marketing perspective should be a major consideration for the selection of any crop for export to the northern hemisphere.

The *mode of transportation* from the southern to the northern hemisphere is another crucial determinant. Exporting proteas by ship is clearly far more profitable than by air. This is the case for all flowers with a lower value/mass ratio which can be sent by ship, for instance for greens. More research should be done to develop procedures for refrigerated container transport for a wider variety of flowers. Refrigerated container transport also gives South African exporters an advantage over exporters in landlocked African flower exporting countries such as Zimbabwe and Kenya. Apart from the direct saving, another motivation for sea transport is to avoid crop losses due to unavailable air cargo space in the September-December period when clearing agents prefer to send fruit by plane at the expense of flowers.

The selection of an area with a *suitable climate and soil* is of great importance for *Protea Magnifica*, It will be more than worthwhile to invest more in high potential land in terms of climate and soil conditions for a particular flower to obtain high yields than to sacrifice the high yields for a lower investment in land. It is far less effective to try to correct less favourable climate and soil conditions with costly and often less efficient production practices than to spend more time and money in order to acquire the most suitable land that can be afforded. Careful selection of areas with suitable climate by foreign and local investors can be made easier by using a Geographic Information System (GIS) to identify areas fitting specified climatic requirements.

The decision tree shows that non-control of pests and diseases in flower production for the Dutch flower auctions, known for their strict quality control, is not profitable from a cost saving point of view. At relatively low costs per hectare, producers can avoid highly probable damage that will be disastrous for quality and/or continuity of supply to the auctions. Flower production will increasingly have to follow the principles of Integrated Crop Management as environmental consciousness grows in northern hemisphere countries, driven by retail chain groups using it as a selling point, as in the case of deciduous fruit (cf Kleynhans & Klompenhouer, 1999a,b). The decision tree model can be used to evaluate the impact on profitability of introducing integrated pest management and biological growing practices in flower production.

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