Strategy and risk in farming

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Introduction

Farm management comprises a clearly defined area, namely the economic decision-making process of individual agricultural firms. The issues to be dealt with are complex and relate to production, environment and nature, and to their interaction with the agricultural supply chain on the one hand and rural environment on the other. To produce and market the products desired, agricultural firms use the production factors land, labour and capital (such as capital goods).

Primary production has been greatly advanced thanks to the progress of science and the positive contribution of education and extension. Yields have improved spectacularly, the use of inputs has been greatly increased, and livestock and crop varieties have been bred to make optimal use of these inputs. Simultaneously the objectives of agriculture and land use have broadened and, therefore, farm management has changed over the last 50 years and has become much more complex.

The farmer as a manager deals with controlling the activities on the farm. His management tasks can be described as taking decisions on organization of the production, financing and marketing aimed at meeting the farm objectives in the given and expected circumstances. It is of utmost importance that the farmer focuses on recognizing situations calling for decisions. The management task also explicitly includes leadership, where relevant. Leading the farm means assigning work to farm personnel, and to stimulate, support, coach and control them. Sometimes the concept of 'entrepreneur' is used, just to emphasize that searching for and availing oneself of the opportunities are important and that – looking at the outside world – clear objectives are formulated and executed and that risks are taken (Keuning, 1999).

The successful development of farms depends to a large extent on the way in which decisions are taken and on the information that is used. Because of the many developments and changes in the technological, economic, institutional and legal environments of farms, farmers continually face new opportunities and threats, which are

to be dealt with adequately. To timely recognize opportunities and problems and to utilize or prevent these remains the core of the issue.

This paper gives an overview of issues that are relevant in current farm management. First, three basic theories of farm management will be presented, i.e., decision-making theory, system theory and theory of management by objectives. Next, two new developments will be introduced, namely strategic management and risk management, which deserve more attention theoretically as well as practically. It is the synthesis of strategy and risk that holds a greater value.

Basic theories

In this section, an historical overview is given of three theories that are the basis of farm management, i.e., (1) decision-making theory, (2) system theory, and (3) management by objectives. In some respects the three theories have many things in common, while in other respects they are rather different. The latter especially becomes clear when the major viewpoint from which the theory is developed, is addressed. The first theory refers to farm management as a set of decision-making processes. The second theory studies farming as a system, while the third theory, which is more or less a combination of the first two, considers farming as a goal-oriented system.

Decision-making theory

The management task of the farmer described above can be characterized as making decisions. Decision-making should be considered a process in which a number of stages are distinguished (Simon, 1960; Lindley, 1985; Van Den Tempel & Giesen, 1992; Trip *et al.*, 2001). These include: observing and defining the problem, developing and analysing alternative solutions, making a choice among alternatives, having the decision carried out and evaluating the result of the decision.

The necessity of making decisions arises if the actual situation is different or threatens to be different from the situation desired. To find an adequate solution to a decision problem, merely recognizing the problem is not enough. Also a good problem definition is necessary in which the cause of the problem is referred to.

After the farmer or the manager has defined the problem, a solution is to be found. Generally, this will yield several alternatives. Because the farmer has to make a choice among these alternatives, he will have to weigh the pros and cons of each of the alternatives. The manager will have to opt for the solution that contributes most to meeting his objectives. The objectives serve as choice criteria in weighing the different solutions.

The manager should see to the decision being carried out adequately. In agriculture, as a rule one or a few persons does (do) the management and carries (carry) out the work. This situation will usually cause fewer problems than in large firms with many employees,

As decisions are made under risk and uncertainty, after the decision has been made, it should be considered whether the result desired is obtained. Evaluation yields

new information, which can lead to adjustment of the decision. It can be concluded that the last and first stages of the decision-making process are interlocked: evaluation can be the reason of a new round of going through the decision-making process. Here one can speak of a decision-making cycle.

These stages in the decision-making process are not gone through in a single, linear way. It rather is a diffuse, repeating, non-linear process with different feedbacks (Renkema, 1998). The main problem in the decision-making theory is caused by the fact that the farmer – just like anyone else – is limited by his mental capacity and that his behaviour is subject to subjective-emotional influences (Miller, 1956; Keuning, 1999). It also means that the farmer as decision-maker cannot possibly know all the alternatives. This means that in weighing the alternatives the farmer cannot be entirely rational and that all kinds of subjective factors play a role. In the 1950s Simon (1960) termed the concept 'bounded rationality'.

The continuous thread that runs through the decision-making model is information and information supply (King, 1978; Harsh *et al*, 1981, Huirne, 1990). In each of the stages indicated, information plays an essential role. Without information the decision-making process cannot happen. The value of information is considered the economic benefit of better decisions minus the cost associated with collecting, processing and using the information (Hardaker *et al.*, 1997; Verstegen & Huirne, 2001). Most often the role of information is that of reducing risk and uncertainty. Using the information is in the first instance a matter of economic weighing: are the costs offset by the benefits? All costs are to be considered, including the time the farmer spends on collecting the data. The benefits of information are especially effectuated through better and more rapidly taken decisions.

System theory

The system theory is concerned with the concept of 'system' (Davis & Olson, 1985; Alter, 1999). A general model of a system – for example an agricultural firm – consists of input, processing and output (Harsh *et al.*, 1981; McDonnell & Dillon, 1992; Unnevehr, 2000). Here a system is an organizational unit consisting of a number of interlocked sub-systems that in many cases also includes the farm household. The system theory presupposes that the choice behaviour within the system is aimed at attaining specific objectives. This means that behaviour and performance of the complete system cannot be inferred entirely from behaviour and performance of each of the sub-systems. For a successful system it is of utmost importance how these sub-systems match and how the system operates in its environment.

Applied to goal-oriented systems like agricultural firms, the system theory propounds two important issues. First, not only physical and biological processes are involved, but also socio-economic ones such as decision-making under risk and uncertainty. Second, understanding a system requires an approach in which the objectives of the system are focused on and in which different strategies will have to be developed to attain these objectives.

In the system theory the agricultural firm is considered a unique, stochastic, open and dynamic system with generating income as a goal (money as well as in kind). The

uniqueness is connected with location, history, means and the people of the farm. The stochastic character of the system is connected with behaviour of people, crops and animals, and with the uncertain character of the environment in which the system functions. Furthermore, the agricultural firm is considered a dynamic and 'open' system, that is to say a system with a continuous interaction with its environment.

Input of the system of the agricultural firm can be subdivided into physical input, such as land, water, buildings and machines, and non-physical input such as knowledge, experience and management skills. Physical input can generally be specified and measured quite simply. Measuring non-physical input, however, is much more difficult. Examples are: social relations, formal and informal organizational structures and matters as creditworthiness.

Theory of 'management by objectives'

The agricultural firm can be defined as a goal-oriented system. Formulating the objectives is essential and directional for decision-making within the firm. 'Management by objectives' is a way of managing in which agreements are made about the objectives to be attained and results to be gained within a certain time period (Harsh *et al.*, 1981; Keuning, 1999). It is done by effectuating the three management functions: planning, implementation and control (Simon, 1960; Boehlje & Eidman, 1984). These three functions are closely related to the stages in the decision-making process, and together form a cycle. Three mutually strongly related application areas can be distinguished in which the farmer as a manager should be active: production, marketing and finance (Boehlje & Eidman, 1984; Barry *et al.*, 2000).

'Management by objectives' answers some important questions the manager is faced with, namely: (1) what products should be produced? (2) how should these products be produced? (3) how much of each product should be produced? (4) where, when and in what quantity should inputs be purchased? (5) where and when should the products be sold?, and (6) what is the best capital structure of the business? (Boehlje & Eidman, 1984; Castle *et al.*, 1987; Casavant *et al.*, 1999).

As has already been pointed out, the answer to all these questions depends on the objectives the entrepreneur wants to realize (Casavant *et al.*, 1999). Possible objectives are maximizing income, attaining a high production level and guaranteeing the continuity of the farm. Generally, entrepreneurs have several goals, which will have to be weighed one against another. The objectives might, for that matter, be subject to change as time elapses (Boehlje & Eidman, 1984; Trip *et al.*, 2001).

Thus far, a brief overview of the relevant theories has been presented, which together form the basis for farm management. These theories are a good starting point to analyse, judge and improve economic choices of agricultural firms. Next, two important developments are introduced and discussed: strategic management and risk management.

Strategic management

Strategic management can be described as a complex of decisions aimed at an active steering of the firm from the existing situation towards the one desired and an evaluation of this strategy at regular or irregular intervals. It comprises formulating the strategic plan, implementing it and evaluating – during the process and afterwards – whether the actions will lead or have led to the goals intended. So it is based on the three basic theories described in the previous section.

Strategic management includes various elements the most important of which are the firm's mission, the internal and external analyses and the synthesis (Wheelen & Hunger, 1998; David, 2001; Grant, 2002).

The firm's mission is the most abstract representation of the objectives of the firm. In the mission the entrepreneur gives answers to three questions: who are we?, what are we doing? and where do we want to go? This statement serves as a point of departure for dealing with the firm and thus for strategic decision-making. If we want to define the firm's mission, the core activities of that firm have to be defined first. A core activity reflects the right for a firm to exist.

The internal analysis is the basis of strategic planning. It is an investigation into the possibilities of a firm and serves as a means to identify its strong and weak points. 'Strong' and 'weak', however, are relative concepts that only carry meaning against the background of the objectives to be realized and in comparison with competing firms. Only points are included that are decisive as to whether a firm is a success or a failure, or in other words, whether or not it realizes the strategy planned.

Not only insight into the strong and weak points of the firm, but also the opportunities and the threats from the environment the entrepreneur and his firm face are of vital importance for attaining the firm's mission. The following categories of external factors are important for the development of the firm: social, technological, economic, political and ecological factors. External analysis is a systematic exploration of the environment for factors that are relevant to achieve the goals and to realize the strategy. The result of the external analysis is a description of the opportunities and threats for the firm. An opportunity is a possibility or market in which the firm, dependent on its mission, can operate. A threat is a development or trend that, without action taken by the firm, could lead to deterioration of the possibilities of realizing the firm's mission.

The last element is the synthesis in which the firm's mission (what does the entrepreneur want?) and the internal and external analyses (what is possible?) are combined. This results in the strategy to be pursued. There are many ways to devise a strategy, for example, the SWOT analysis (Strengths, Weaknesses, Opportunities and Threats). The SWOT analysis is a universally useful method that departs from a matrix in which strengths and weaknesses of the firm are confronted with the opportunities and the threats from the environment.

The manager should determine the best strategy on the basis of the SWOT analysis. A strategy represents the contents and the character of the activities of the firm in relation to its environment. Moreover, it outlines the actions that are going to be taken in the coming years. Obviously, strategies are extremely firm specific and also depend on the manager's ambition level. The following ambition levels with corresponding

building blocks for the strategy can be distinguished (Courtney *et al.*, 1997):

1. *Shape the future.* This means that the manager plays an active role in influencing the future of his firm and his market. Important building blocks for such a strategy are the so-called big bets, i.e., risky activities with enormous positive effects in one, or some but significant negative effects in other scenarios.
2. *Adapt to the future.* This means that the current and expected market is considered a given and that the manager wins through speed, agility and flexibility in recognizing and capturing opportunities in existing markets. Important building blocks for such a strategy are the so-called options, i.e., activities that in most cases yield a positive payoff in some and a (small) negative effect in other outcomes.
3. *Reserve the right to play.* This means that the manager invests sufficiently to 'stay in the market', but does not take any premature commitment. Important building blocks for such a strategy are the so-called no-regret moves, i.e., activities leading to small positive payoffs in any conceivable scenario.

Tailoring to the needs is important in all strategies. If a strategy is applied that is not tailored to the firm and that the entrepreneur cannot deal with, all prior analyses will be of no avail. That is why it is important that the farmer himself goes through all stages. Much research is still needed to further develop this field of strategic management. To properly understand the interaction between firm and environment the incentive-based principal-agent theory of Milgrom & Roberts (1992) is of great importance. This theory relates to the general problem of motivating a person or party (agent) who acts on behalf of the other person or parties (principal). The two persons or parties usually have opposite interests. Also, there is often non-transparent and asymmetric information, i.e., one person or party has more or better information than the other. In this type of research it is desired to develop methods to timely recognize the relevant external incentives (i.e., opportunities and threats). Methods should be developed to meet these incentives by specific measures on the farm. Here it is important for individual farmers to determine which strategy is recommendable in which circumstances, and for governments to see how farmers respond to particular (policy) incentives. So the principal-agent theory touches the underlying decision-making theory as well as the system theory. This type of research is rather complex because decisions are often irreversible and have to be taken under risk and uncertainty.

Risk management

The concepts of 'risk' and 'uncertainty' have already been referred to several times. It is time to elaborate upon them. The meanings of 'risk' and 'uncertainty' are similar (Hardaker *et al.*, 1997). Uncertainty is the result of incomplete knowledge. Risk is defined as uncertain consequences or results at the moment of making decisions. Risk particularly concerns exposure to unwanted, negative consequences. Risk management is about the way in which managers deal with risk and uncertainty (Meuwissen *et al.*, 1999, 2001; Huirne *et al.*, 2000; Van Asseldonk *et al.*, 2001).

Current Dutch government policy has increasingly been aimed at creating an open market system. This results in, amongst other things, the fact that agriculture in the

Netherlands is increasingly confronted with price-making in international markets, such as the world market, which generally means lower and definitely more fluctuating prices (Huirne *et al.*, 1997; Meuwissen *et al.*, 1999). By further modernization of the sector there are also increasing economic consequences. Dealing with such risks, i.e., risk management, is getting more and more important, not only for individual farmers, but also for all firms in the agricultural supply chain.

Many activities of an agricultural firm take place outdoors and are weather dependent. The agricultural sector also deals with live material, which makes it an outstanding example of being exposed to risks (Anderson *et al.*, 1977; Hardaker *et al.*, 1997; Barry *et al.*, 2000; Van Asseldonk *et al.*, 2001). Production risks are caused by the unpredictable character of the weather and hence uncertainty as to the physical yield of animals and crops. Diseases and infestations can have a great influence on farm results, as the Classical Swine Fever outbreaks in 1997/1998 and the Foot-and-Mouth Disease outbreaks in 2001 clearly showed.

Moreover, the prices of production means most often purchased (such as concentrates, fertilizer, pesticides and machines) and of products sold (such as milk, tomatoes and cut flowers) are not known, at least not at the moment decisions on these have to be taken. As already mentioned, farmers are increasingly exposed to price-making forces in unpredictable markets. Thus, market and price risks are important factors.

Governments form another source of risk to farmers. Changes in laws and regulations with respect to running the farm can have far-reaching consequences for farm results. Examples are the continuing changes in the regulations as to environment, pesticides, animal diseases and animal welfare. On the other hand, governments have also set off particular risks (up to now).

Farmers working on their farms are a risk themselves to the profitability and continuity of the farm. The farm's survival may be threatened by death of the owner, or by divorce of a couple together running the farm. Long-term illness of the owner or employees can also cause considerable losses or can increase the costs considerably. Such risks are called human or personal risks.

There are also financial risks involved (Belli *et al.*, 2001), related to the financing of the farm. Using borrowed capital – such as mortgages and the like – means that first the interest needs to be paid before increasing one's equity capital. For farms with relatively much debt capital – for example, as a result of large investments – little will be left as a reward to one's equity capital at times of high interest rates. Only farms that are entirely equity-financed are not subject to such financial risks, but yet can sustain capital loss. Other risks in connection with the use of credit and loans are uncertain interest rates and not being able to obtain a loan or mortgage.

So risks are unavoidable and influence almost any decision the farmer takes. That is to say risks are there, but can be counteracted. The farmer should anticipate such risks by his management. But in what way can risks be reduced? There are two categories of measures to reduce risks: taking measures within the farm and sharing risks with others (Hardaker *et al.*, 1997; Huirne *et al.*, 1997; Belli *et al.*, 2001).

About many uncertain events (extra) information can be obtained easily. For example, asking for the weather forecast, analysing feed or soil samples and consulting experts. Also particular risks can possibly be avoided or prevented. It is known that

certain activities carry more risks than other. Reducing farm contacts can, for example, reduce the risk of disease introduction considerably. Another good strategy to minimize risks is not to put all one's money on a single farm activity. By selecting a mixture of activities, risks can be considerably reduced. The same holds for having various suppliers and buyers. Flexibility can be mentioned as a last measure at farm level. Flexibility refers to how well a farm can anticipate changing conditions. For example, by investing in multi-purpose machines and buildings.

The second set of measures refers to sharing risks with others (Hardaker *et al.*, 1997; Huirne *et al.*, 1997). One possibility here is buying insurance. At the moment there are several types of insurance available, with which, by payment of a premium, risks can be reduced or even eliminated. The farmer can also conclude contracts – for example with suppliers and buyers – in which price agreements are laid down. Agreements can be made on the duty to deliver and to buy, as on the quality of the products or raw materials. Lastly, by using the futures market, price risks can largely be eliminated. The futures market is not yet very well known in the Netherlands, but in the US it is popular for a number of agricultural products.

Most farmers try to reduce risks when they face decisions that may have a considerable influence on their income or wealth (Anderson *et al.*, 1977; Hardaker *et al.*, 1997; Belli *et al.*, 2001). Examples of such decisions are sizeable investments in milk quotas or in a second farm enterprise. The attitude of reducing exposure to risks is called risk aversion. A risk-averse person is willing to sacrifice part of his income to reduce risks. This consideration serves as a means to make a choice among the above measures. However, reducing risks will generally involve a cost.

Managers, policy makers and researchers alike often have a binary way of dealing with risk and uncertainty. One either assumes certainty and an exactly predictable future, or uncertainty and an entirely unpredictable future. In the latter case further analyses are often omitted and decisions are made either intuitively or not made at all. Under- as well as overestimating the risks is potentially dangerous. Further analysis learns that there are at least four levels of risk and uncertainty (Courtney *et al.*, 1997):

1. A clear-enough future; a single forecast precise enough for the purpose of decision making.
2. Alternate futures; a few discrete outcomes that define the future.
3. A range of futures; a whole range of possible outcomes.
4. True ambiguity; no basis to forecast the future.

Level 1 and level 4 are extreme situations and do not very often occur in practice. So it is all the more distressing that many managers and advisors regularly operate at these levels of risk. Particularly working at level 1 where calculations are carried out and advice is given under the assumption of complete information and certainty, is alarming.

Synthesis of strategy and risk

Strategy and risk are closely connected. This also holds for strategic management and risk management. A strategic plan with insufficient attention to risk can be mislead-

ing. Risk management without attention to strategy is aimless and often leads to treatment of the symptoms. The synthesis of strategy and risk can take place in a number of steps. First the firm's mission and the external and internal analyses are carried out. Then the type and extent of the risks and uncertainties are assessed. Subsequently, the ambition level and corresponding building blocks are selected, after which, on the basis of the preceding factors, the optimal strategy is formulated. The strategy is a combination of individual actions. Lastly, the strategy is applied and the process controlled.

Within the strategy, the extent of risk the manager is willing to run should be weighed against the changes in the farm considered necessary for the future. So each strategy is farm specific. A number of generic strategies result from the synthesis of strategy and risk (Wheelen & Hunger, 1998; David, 2001; Grant, 2002).

Stability strategy

Stability strategy aims at remaining in business in the current field (reserve the right to play). It restricts itself to existing products and markets, and strategic decisions relate to optimizing current management (no-regret moves). However, the risk of this stability strategy is that insufficient attention is paid to buyers' demands for the products and to other developments in the environment of the firm, for example, in the fields of politics and legislation.

Internal growth

Internal growth particularly aims at expansion of existing activities (adapt to the future). Its objective is to obtain a broader basis for the firm (options), by means of increase in scale, resulting in a lower cost price per unit of product. The advantage of this strategy is that the knowledge necessary for these activities is already present. The risk is that it requires larger organizational capacities of the manager.

Diversification

With diversification the enterprise is expanded by new product-market combinations that are not or hardly correlated, which holds for new combinations towards shaping the future by big bets. Spread of risk and possible synergy effects are often considered advantages of this strategy. The disadvantage is that knowledge and skills have to be broadened considerably. A variant of diversification is vertical integration aiming at activities that include various stages in the supply chain. This is realized by expansion with related activities, which result in new products.

Restructuring

Restructuring is particularly applied in enterprises that have structural problems. Only drastic intervention in the structure can save the enterprise (big bets). Restructuring, also called downsizing, rightsizing or delayering, involves reducing the size of the firm

in terms of activities and/or the firm's organizational structure. This reduction in size is intended to improve both efficiency and effectiveness. The only objective of this strategy is survival; there often is no room for other objectives.

Final remarks

The agricultural firm is constantly developing. The farm is and remains an essential player in the agricultural supply chain and in the rural area. The differences between the agricultural sector and the rest of the industry are getting smaller and smaller. Industrial characteristics of this 'new' agricultural sector are (after Boehlje, 1996): (1) importance of manufacturing processes (versus commodities), (2) a systems approach to production and distribution, (3) separation and realignment of the stages in the food chain for the purpose of efficiency and low cost-price, (4) negotiated co-ordination among these stages and with the environment (rural area), (5) new kinds of risk, (6) concern about system power and control, and (7) a more important role for information. This again implies a risk consideration within the strategy selection.

References

Alter, S., 1999. Information Systems: a Management Perspective (3rd ed.). Addison-Wesley, Reading, Massachusetts, 523 pp.

Anderson, J.R., J.L. Dillon & J.B. Hardaker, 1977. Agricultural Decision Analysis. Iowa State University Press, Ames, Iowa, 344 pp.

Barry, P.J., P.N. Ellinger, J.A. Hopkin & C.B. Baker, 2000. Financial Management in Agriculture. Interstate, Danville, Illinois, 678 pp.

Belli, P., J.R. Anderson, H.N. Barnum, J.A. Dixon & J.-P. Tan, 2001. Economic Analysis of Investment Operations. WBI Development Studies, The World Bank, Washington, D.C., 264 pp.

Boehlje, M.D., 1996. Industrialization of agriculture. What are the implications? *Choices*, First Quarter 1996, pp. 30–33.

Boehlje, M.D. & V.R. Eidman, 1984. Farm Management. Wiley, New York, 806 pp.

Casavant, K.L., C.L. Infanger & D.E. Bridges, 1999. Agricultural Economics and Management. Prentice Hall, Upper Saddle River, New Jersey, 434 pp.

Castle, E.N., M.H. Becker & A.G. Nelson, 1987. Farm Business Management: the Decision-Making Process (3rd ed.). Macmillan, New York, 413 pp.

Courtney, H., J. Kirkland & P. Viguerie, 1997. Strategy under uncertainty. *Harvard Business Review* 75 (6): 67–79.

David, F.R., 2001. Strategic Management. Prentice Hall, Upper Saddle River, New Jersey, 351 pp.

Davis, G.B. & M.H. Olson, 1985. Management Information Systems. Conceptual Foundations, Structure and Developments. McGraw-Hill International, New York, 693 pp.

Grant, R.M. 2002. Contemporary Strategy Analysis (4th ed.). Blackwell Publishers, Oxford, 452 pp.

Hardaker, J.B., R.B.M. Huirne & J.R. Anderson, 1997. Coping with Risk in Agriculture. CAB International, Wallingford, 274 pp.

Harsh, S.B., L.J. Connor & G.D. Schwab, 1981. Managing the Farm Business. Prentice Hall, Englewood Cliffs, New Jersey, 384 pp.

Huirne, R.B.M., 1990. Basic concepts of computerized support for farm management decisions. *European Review of Agricultural Economics* 17: 69–84.

Huirne, R.B.M., J.B. Hardaker & A.A. Dijkhuizen (Eds.), 1997. Risk Management Strategies in Agriculture: State of the Art and Future Perspectives. Mansholt Studies No. 7, Wageningen Agricultural University, Wageningen, 319 pp.

Huirne, R.B.M., M.P.M. Meuwissen, J.B. Hardaker, & J.R. Anderson, 2000. Risk and risk management in agriculture: an overview and empirical results. *International Journal of Risk Assessment and Management* 1: 125–136.

Keuning, D., 1999. The Principles of Management (2nd ed.), Educatieve Partners Nederland, Houten, 644 pp. (In Dutch)

King, W.R., 1978. Strategic planning for management information systems. *MIS-Quarterly* 2: 27–37.

Lindley, D.V., 1985. Making Decisions (2nd ed.). Wiley, London, 207 pp.

McDonnell, D.J. & J.L. Dillon, 1997. Farm management for Asia: A systems approach. Farm Systems Management Series No. 13, Food and Agriculture Organization of the United Nations (FAO), Rome, 355 pp.

Meuwissen, M.P.M., R.B.M. Huirne & J.B. Hardaker, 1999. Income Insurance in European Agriculture. Scientific Report EU-Project, European Economy No 2, DGII, Brussels, 95 pp.

Meuwissen, M.P.M., R.B.M. Huirne & J.B. Hardaker, 2001. Risk and risk management: an empirical analysis of Dutch livestock farmers. *Livestock Production Science* 69: 43–53.

Milgrom, P. & J. Roberts, 1992. Economics, Organization and Management. Prentice Hall, Englewood Cliffs, New Jersey, 621 pp.

Miller, G.A., 1956. The magical number seven, plus or minus two: Some limits on our capacity for processing information. *The Psychological Review* 63: 81–97.

Renkema, J.A., 1998. Farm management: a matter of going up and down. Valedictory Wageningen Agricultural University, Wageningen, 29 pp. (In Dutch)

Simon, H.A., 1960. The New Science of Management Decision. Harper and Row, New York, 50 pp.

Trip, G., R.B.M. Huirne & J.A. Renkema, 2001. Evaluating farmers' choice processes in the laboratory: workshops with flower producers. *Review of Agricultural Economics* 23: 185–201.

Unnevehr, L.J. (Ed.), 2000. The Economics of HACCP – Costs and Benefits. Eagan Press, St. Paul, Minnesota, 412 pp.

Verstegen, J.A.A.M & R.B.M. Huirne, 2001. The impact of farm management on value of management information systems. *Computers and Electronics in Agriculture* 30: 51–69.

Van Asseldonk, M.A.P.M., M.P.M. Meuwissen & R.B.M. Huirne, 2001. Stochastic simulation of catastrophic hail and windstorm indemnities in the Dutch greenhouse sector. *Risk Analysis* 21: 761–769.

Van Den Tempel, F.C.A. & G.W.J. Giesen, 1992. Farm Management. Educaboek, Culemborg, 456 pp.

Wheelen, T.L. & J.D. Hunger, 1998. Strategic Management and Business Policy. Addison-Wesley, Reading, Massachusetts, 1096 pp.