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AN ECONOMIC EVALUATION OF SOME CROP SUCCESSION SYSTEMS UNDER DRYLAND CONDITIONS IN THE FREE STATE MIDLANDS

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ABSTRACT

The Free State Midlands is a high-risk area where summer and winter crops are cultivated under various rotational and fallow systems. Six such systems in general use were identified and with the aid of crop growth simulation models and weather input data long-term yield data were generated. The economic results of the various systems were evaluated for a period of 24 years (1960 to 1983) for a hypothetical farming unit of 600 ha. The various systems were evaluated in respect of gross farm production value, margin above variable costs, net farm income and farm profit, based on the average yields for the period at 1983 prices. The annual farm profit figures, purchasing power and financial risk were also evaluated. It appears that the protracted wheat fallow system is the most economic of the six. It is also clear that the financing risk can be reduced for both the farmer and the financial institution by coupling the granting of loans to the physio-biological aspects of a farming unit. Furthermore, recommendations of crop choices based mainly on gross margins are laden with potential dangers.

INTRODUCTION

Crop producers in the Free State Midlands have found that the inclusion of a summer crop in an existing winter crop production system, with accompanying longer fallow periods, leads to increased cereal yields per unit of area and a reduction in weed problems and root diseases (Van Aswegen and De Jager, 1980). These findings led to questions being posed by the crop producer concerning the economic justification for crop rotation and fallow land systems. The purpose of this article is to make a long-term economic evaluation of crop rotation and fallow land systems and to identify the most economical system of those investigated.

PROCEDURE

In order to determine the long-term profitability of a crop succession system long-term yield data are essential. Because of a serious lack of research data concerning crop rotation and fallow land systems long-term yield data had to be generated by means of crop growth models.

For this purpose a hypothetical farming unit of 600 ha of arable land was constructed, with land and agricultural meteorological characteristics similar to those of the research station at Glen as representative of the area investigated. The area of investigation in which the study was carried out was limited to the fairly homogeneous farming area number 4051 of the Free State Midlands. The yields of wheat and maize were determined with the help of the dynamically deterministic physical-biological PUTU growth models (De Jager, 1981) for the farming unit for a period of 24 years (1960-1983). The yield data were used to evaluate economically the following six popular crop succession systems:

(i) Wheat monoculture - wheat is cultivated on the same land annually, with a short fallow period of approximately five months;
(ii) maize monoculture - maize is cultivated on the same lands annually, with a short fallow period of approximately five months;
(iii) long fallow wheat - wheat is cultivated on the same lands every second year, with a long fallow period of approximately 17 months;
(iv) wheat-wheat-long fallow - wheat is cultivated on the same lands for two successive years, with a long fallow period of 17 months between every two-year cycle;
(v) wheat-maize crop rotation - wheat is cultivated alternately with maize on the same lands, with a long fallow period of approximately 10 months between maize and wheat and a long fallow period of approximately 12 months between wheat and maize; and
(vi) wheat-wheat-maize crop rotation - wheat is cultivated on the same lands for two successive years alternately with maize, with a long fallow period of approximately 10 months between maize and first-year wheat, a short fallow period of approximately five months between first-year wheat and second-year wheat and a long fallow period of approximately 12 months between second-year wheat and maize.

Various other systems are also still being used in the investigation area, but we had to be content with those systems using wheat and/or maize because there were no growth models available for other crops.

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YIELD DATA

In view of its development background (Singels, 1983) a PUTU model for wheat was used to calculate specific wheat yields after a long fallow period and the PUTU maize growth model (De Jager *et al.*, 1983) was used to calculate maize yields after a short fallow period. Maize yields after a long fallow period were taken as constantly 30 per cent higher than the yield after a short fallow period in accordance with the findings of Van Aswegen and De Jager (1980). A rectilinear relationship between long fallow and short fallow wheat yields was deduced from experimental results (Van Rooyen, 1984) in the investigation area. This significant relationship (P 0,01) was used to deduce short fallow wheat yields from the model-calculated long fallow wheat yields (Grobbelaar, 1985).

Over the 24 year period the average long fallow wheat yield was 2,061 tons per hectare, while the average wheat yield after a short fallow period was 1,169 tons per hectare. The difference between the two averages is very significant (P 0,001). The yield per hectare planted was therefore approximately 76 per cent higher for long fallow wheat than for monoculture wheat, which closely approximates the 70 per cent found by Van Aswegen and De Jager (1980) in studies of practices undertaken in the investigation area. The difference between these yields was greater in years with unfavourable weather conditions and vice versa. The coefficient of variation in long fallow wheat yields was 19,6 per cent, whereas that of monoculture wheat was 51,9 per cent (Grobbelaar, 1985).

The average monoculture maize yield during the period was 1,7 tons per hectare of cereal and 1,063 tons per hectare of hay and the average long fallow maize yield was 2,21 tons per hectare of cereal and 1,381 tons per hectare of hay. The coefficient of variation in yields was 49,7 per cent in both cases.

These calculated yields were, in view of the lack of actual measured yields, used as the best alternative for research results and the economic evaluation was therefore based on them.

ECONOMIC EVALUATION

The expected financial results of and the financial risk connected with a certain crop succession system are important points in the economic evaluation of and eventual choice between different crop succession systems.

Financial results

In order to determine the financial results of the various systems, farm profit analyses (rather than merely gross margin analyses) should be made of the farm unit for each of the various systems. The reason for this is that crop producers in the investigation area suspect that there are substantial differences in capital and labour needs between various systems (Van Aswegen, 1984).

The importance of a farm profit analysis is clearly discernible from Table 1, which shows the gross farm production value, farm margin above variable costs, net farm income and farm profit of each system (South Africa (Republic), Department of Agriculture, 1983). The calculations were made on the basis of the average yield of each system for the 24 year period (1960 to 1983) and at the present (1983) prices. From this it is clear that the system with the highest average gross farm production value (maize monoculture) realised the lowest average farm profit for the 24 year period.

The system with the lowest average gross farm production value (long fallow wheat) realised the second highest average farm profit. Furthermore, it is also significant that the percentage differences between the financial results of the various systems changed radically as the calculations were taken further than gross farm production value.

Because there is a difference between the systems in the coefficient of variation for yields (Grobbelaar, 1985), the farm profit analyses on the basis of average yields may give a distorted picture of the actual financial result.

It is therefore essential to base annual profit analyses on the yield for the particular year. In Table 2 a comparison is made between the various crop succession systems on the basis of annual farm profit analyses. From this it can be seen that the system with the lowest average farm profit (maize monoculture) was one of the three systems with the highest farm profit in seven of the 24 years, but was lowest and had a negative farm profit in 11 of the 24 years. The system with the highest average farm profit (wheat-maize crop rotation) was one of the three systems with the highest farm profit in 19 of the 24 years, while the farm profit was, in fact,

TABLE 1 - Gross farm production value, farm margin above variable costs, net farm income and farm profit of the various crop succession systems (average yields for the period 1960 to 1983 at 1983 prices)

System		Gross farm production value	Farm margin above variable costs	Net farm income	Farm profit
				R	
(i)	Wheat monoculture	185 099	95 885	62 162	41 762
(ii)	Maize monoculture	195 774	89 381	52 697	24 707
(iii)	Long fallow wheat	164 777	106 986	82 081	68 833
(iv)	Wheat-wheat-long fallow	171 551	102 204	70 229	52 397
(v)	Wheat-maize-crop rotation	194 680	121 590	88 007	71 980
(vi)	Wheat-wheat-maize crop rotation	192 285	114 859	81 115	64 642

Source: Grobbelaar, (1985)

negative in three of the 24 years, but was not lowest in any year. The farm profit of the long fallow wheat system was in fact poorest in three of the 24 years, but not negative in any year.

TABLE 2 - Comparison between the various crop succession systems on the basis of annual farm profit figures (1960-1983)

System		Number of years Highest	One of the three highest	Lowest	Negative
(i)	Wheat monoculture	6	9	9	6
(ii)	Maize monoculture	3	7	11	11
(iii)	Long fallow wheat	6	14	3	0
(iv)	Wheat-wheat-long fallow	0	7	1	5
(v)	Wheat-maize crop rotation	9	19	0	3
(vi)	Wheat-wheat-maize crop rotation	0	16	0	6

Because the farm profit figures in Table 2 were calculated at present (1983) prices, constant price ratios were assumed between producer prices and the prices of farm requirements over the 24 year period. The study of price indices, however, proves the contrary (Scholtz, 1983) and therefore the annual farm profit figures were adjusted by using the price indices of wheat, maize and farming requirements (South Africa (Republic), Department of Agriculture, 1984). Therefore the annual farm profit figures were calculated at prices ruling during the individual years. These absolute farm profit figures showed that the systems in which mainly wheat was cultivated were more often among the three systems with the highest farm profit than in the case of the calculations at constant (1983) prices in Table 2. Four of the six systems were also negative in fewer years than in the case of the calculations in Table 2 (Grobbelaar, 1985).

In order to take account of the time value of money also, the total purchasing power (in 1983) of the annual farm profit figures of each system was calculated. Because the farm profit in the case of this hypothetical farm unit is more or less equal to the amount the farmer spends on consumer items, the annual farm profit figure can also be measured by its purchasing power in the year in which it was received. The results are shown in Table 3.

TABLE 3 - Total purchasing power (in 1983) of the annual farm profit figures of the various crop succession systems (at 1983 prices)

System		Total purchasing power R
(i)	Wheat monoculture	1 520 300
(ii)	Maize monoculture	814 966
(iii)	Long fallow wheat	2 101 090
(iv)	Wheat-wheat-long fallow	1 785 402
(v)	Wheat-maize crop rotation	2 096 606
(vi)	Wheat-wheat-maize crop rotation	1 972 651

It is obvious from a financial point of view that there is little to choose between the long fallow wheat and the wheat-maize crop rotation system. Even the wheat-wheat-maize crop rotation system had good results. It is significant that the total purchasing power of the maize monoculture system is less than 50 per cent of that of four of the other five systems. This can be ascribed to the 11 negative farm profit figures for this system (see Table 2).

Financial risks

The financial risks of the probability of losing one's owner's interest in the undertaking was calculated for the various crop succession systems by using a method illustrated by Barnard and Nix (1979). According to this, the financial risks of each system could be expressed in terms of the probability of not being capable of meeting the fixed obligations of the farm unit in a specific year (Grobbelaar, 1985).

These probabilities are shown in Table 4. According to this, the probability of experiencing a deficit in a specific year is smallest in the case of the long fallow wheat system, namely 11,3 per cent (or 1 in 8,9 years). This probability is considerably higher with the wheat-maize crop rotation system, namely 22,8 per cent (or 1 in 4,4 years). In the two monoculture systems the probability is about 50 per cent (or 1 in 2 years), which is very risky. Even if the farm unit had no mortgage or medium-term debt, the monoculture systems would still be more risky than the long fallow wheat and wheat-maize crop rotation systems with mortgage and medium-term obligations. In the absence of mortgage and medium-term obligations the probability of a deficit is reduced with the application of the long fallow wheat system to 0,2 per cent (or 1 in 500 years). This calculation has far-reaching implications for the way in which financial institutions finance farmers. It shows, undeniably, that the financing risks for both the farmer and the institution can be reduced by linking the granting of loans to the physical-biological aspects of a farm unit's production system. Financing institutions such as agricultural co-operatives may even consider linking the amount of financial help to probabilities such as those calculated in Table 4. The lower the financial risk the lower the interest rate may be, so that the producer may be encouraged to use lower risk farming activity enterprises.

TABLE 4 - Probability of a deficit for the various crop succession systems at various debt positions (1983 prices)

System		Probability (%) With mortgage and medium-term debt	Without mortgage and medium-term debt
(i)	Wheat monoculture	47,7	23,9
(ii)	Maize monoculture	54,2	27,2
(iii)	Long fallow wheat	11,3	0,2
(iv)	Wheat-wheat-long fallow	34,2	6,4
(v)	Wheat-maize-crop rotation	22,8	3,1
(vi)	Wheat-wheat-maize crop rotation	29,5	6,2

SUMMARY

On the basis of the above results the long fallow wheat system can be regarded as the most economical system of the six crop succession systems investigated. It also appeared that an economic evaluation should be made right to farm profit level, on the basis of long-term annual yields and at the ruling prices of each particular year.

In the light of the method(s) followed to calculate crop yields for the purposes of this study, conclusions and recommendations forthwith on the basis of these yields would be risky. It is nevertheless clear that the monoculture systems do not fare well and can with a reasonable amount of certainty be labelled undesirable in the area of the investigation.

Research in the field of crop rotation and fallow land systems should, in future, make provision for the collection of relevant information so as to be able to make an economic evaluation as above. It is therefore essential that the agricultural economist and the agricultural meteorologist should be involved in the original planning of such research projects.

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