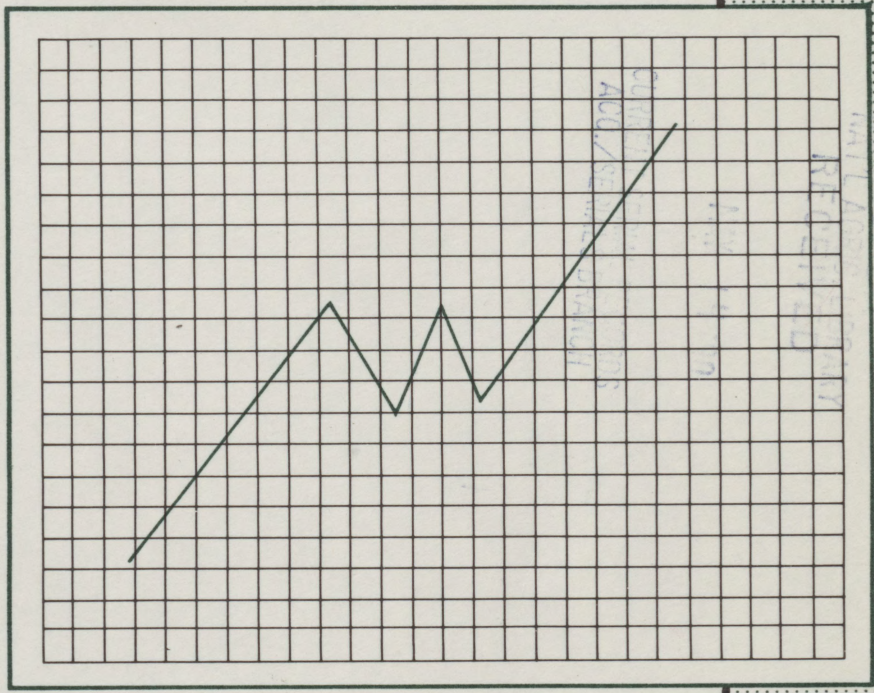

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RISK ANALYSIS OF MAIZE CULTIVATION SYSTEMS IN THE NORTH-WESTERN FREE STATE*

by J. HOUGH and J.A. GROENEWALD**

ABSTRACT

The risks involved in seven different cultivation systems as regards yield, net margins and net margins per R100 of capital invested were analysed and ordered using stochastic dominance (SD).

Mulch systems are less risky than the conventional systems. This finding agrees with those of similar overseas studies.

First-order and second-order SD produced enough proof of dominance in order to exercise choices. Third-order SD did not provide any additional dominance results. Rank shifts between net margins and net margins per R100 of capital invested occurred.

INTRODUCTION

Different cultivation systems for maize in the North-Western Free State were analysed and it was found, on the basis of a predominantly statistical analysis, that mulch systems are more profitable than conventional systems (Hough & Groenewald, 1987).

In view of the fact that dry-land grain farmers are subject to considerable uncertainties and risks, a risk analysis was necessary as well. A farming operation based on expectations, the attendant risks of which have not been thoroughly taken into account, can be ruined by contingencies against which inadequate precautions have been taken (Du Plessis, 1976: 139). This is especially important with regard to the acceptance of new technology (Anderson, 1974a: 131).

Various methods and techniques are used to analyse risk in agriculture. The work of Jolly *et al.* (standard deviation), Rae (quadratic risk programming), Moscardi *et al.* (regression coefficients), Hildreth (utility functions), Lazarus *et al.* (stochastic simulation) and Anderson *et al.* (stochastic dominance) has provided some of these. According to Anderson (1974a: 131) stochastic dominance holds promise for ordering risky projects or choices.

This article is aimed at describing different orders of stochastic dominance and ordering the risk attached to the seven different cultivation systems in respect of yield, net margins and net margins per R100 of capital invested. Van Rooyen's programme (1985), which is based on the theory of Anderson *et al.* (1977: 313–318), was used for this.

Pertinent remarks will also be made regarding the stability of the systems and the way they react to environmental conditions. The seven systems in Table 1 were evaluated (Hough & Groenewald, 1987).

STOCHASTIC DOMINANCE (SD)

This method describes the grouping of a few variable distributions. The variables for this case were mentioned in the introduction. Three types of groupings or orders of dominance are involved here, namely first-order, second-order and third-order dominance.

SD accepts that preference is a function of a single undetermined amount x or U(x), and writes the ith derivation with regard to x as Ui(x). The preference of the decision maker is therefore built into the utility function

TABLE 1. Cultivation systems† over seven years, 1978/79 — 1984/85

System	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85
Number							
1	N	N	N	N	N	N	N
2	N	CR	CR	CR	CR	CR	CR
3	N	ROR1	ROR1	ROR1	ROR1	ROR1	ROR1
4	N	P(W)	P(W)	P(W)	P(W)	P(W)	P(W)
5	DP(W)	DP(W)	DP(W)	DP(W)	DP(W)	DP(W)	DP(W)
6	P(S)	P(S)	P(S)	P(S)	P(S)	P(S)	P(S)
7	ROR2	ROR2	ROR2	ROR2	ROR2	ROR2	ROR2

†*Explanation of codes*

N – Nardi.
CR – Complete rip.
ROR1 – Rip-on-row, with a cultivation depth of 510 mm.
P(W) – Plough in winter.
DP(W) – Deep plough in winter.
P(S) – Plough in summer.
ROR2 – Rip-on-row, with a cultivation depth of 470 mm.

*Based on an M.Sc.(Agric.) thesis

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Ui(x). Think of two variables (outcomes) with infinitely randomised variable x, as $a \leq x \leq b$, and with frequency functions of f(x) and g(x). These frequency functions are defined as $F_0(x) = f(x)$ and $F_n(R) = \int_a^R F_{n-1}(x)\,dx$, $n > 1$, so that F1 (R) is equal to the cumulative distribution function of f(x). The preference assumptions and the corresponding grouping rules for f in order to dominate g in the different orders of dominance (Anderson, 1974b: 569–570) are set out below.

First-order stochastic dominance (FSD)

Preference assumption	= Decision-makers prefer more of x
Grouping rules	= U1(x) > O F1(x) ≤ G1(x) ... 7.1

The distribution f(x) dominates g(x) in FSD if F1(R) ≤ G1(R) for all R in (a, b) with strong inequality for at least one value of R.

Figure 1 gives a graphic explanation of FSD. F(x) can dominate G(x) only if the F1 curve is lying to the right of the G1 curve. In this curve F1 is dominant (first order) with regard to G_1^d, but not G_1^{n}·

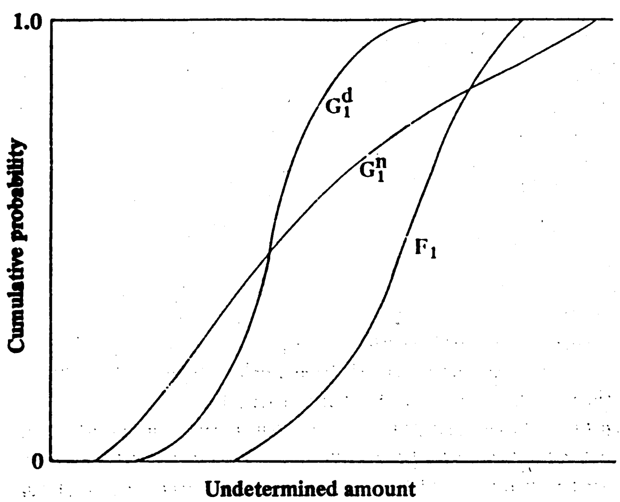


FIG. 1. Illustration of FSD

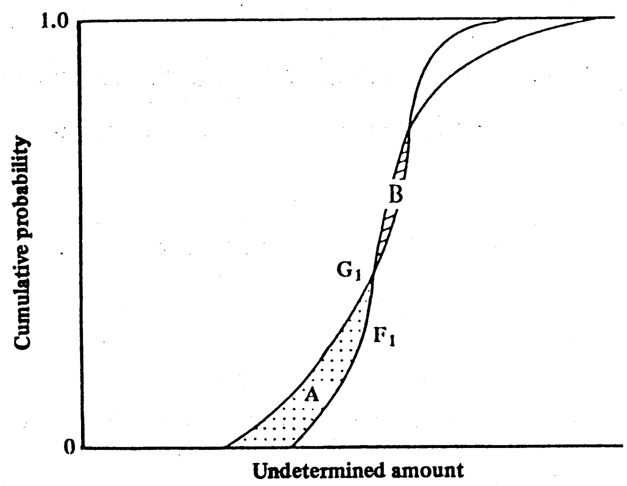
Second-order stochastic dominance (SSD)

Preference assumption = higher quantities of x have a descending value for a decision-maker, for example the 1 000th unit of an income is not as important as the 1st or the 999th unit.

Grouping rule = Ui(x) > o F2(x) < G2(x) ... 7.2

The distribution of f(x) dominates g(x) in SSD if F2(R) < G2(R) for all possible R with strong inequality for at least one value of R.

Figure 2 represents the SSD case graphically, where f is dominant and the F2 curve does not lie to the left of the G2 curve at any point. A further condition for f dominance in the SSD case is that the area A must be larger than area B.



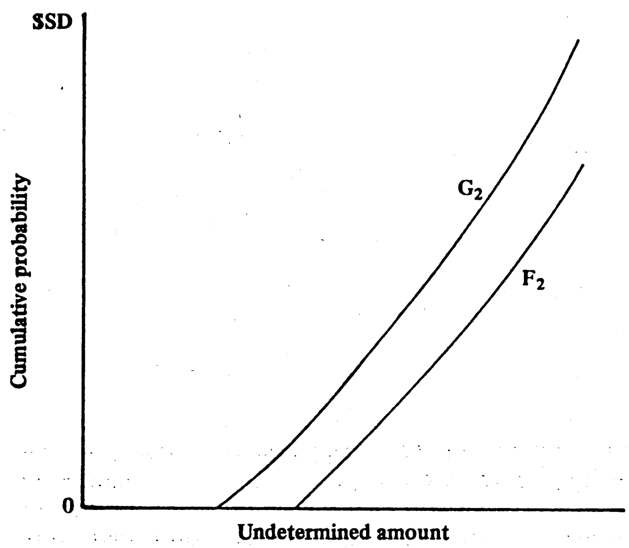


FIG. 2. Illustration of SSD

Third-order stochastic dominance

Preference assumption = as decision-makers become prosperous they become increasingly averse to taking risks.

Grouping rule	U1(x) > o F3(x) ≤ G3(x)	
	U2(x) < o F2(b) ≥ G2(b)	
	U3(x) > o	... 7.3

The distribution f(x) dominates g(x) in TSD if F3(R) ≤ G3(R) for all R in (a, b) with strong inequality for at least one value of R and if F2(b) ≤ G2(b). TSD and SSD may in general be very similar (Anderson *et al.*, 1977: 289).

Various regression and SD curves of cultivation system performance and the three orders of stochastic dominance (effectiveness) were research for the seven cultivation systems. Only the consolidated results of the FSD and SSD are given here. See Hough (1986) for the full series of dot diagrams.

THE RISKS WITH REGARD TO YIELD

The slope, intercept and D parameter for each system are as follows:

System	Slope	Intercept	D parameter
1	0,097	0,284	0,712
2	-0,109	1,055	0,305
3	-0,269	2,000	0,240
4	0,720	-4,295	0,256
5	0,132	-0,937	0,349
6	-0,013	-1,633	0,828
7	-0,559	3,446	0,293

The negative intercepts of the regression lines with the conventional systems (systems 4, 5 and 6) are an early indication that they are, relatively speaking, poorer than the other systems.

The negative slopes of systems 2, 3 and 7 together with the positive intercepts confirm that they are relatively speaking superior in poor conditions and less competitive in more favourable conditions.

The consolidated figure 3 shows that system 6 (summer ploughing) is dominated by all the other systems and is therefore the most risky of the seven. It is also apparent that systems 4, 5 and 6 are definitely dominated by every one of the other systems in respect of FSD. There is, however, no real indication of first-order dominance between systems 1, 2, 3 and 7.

With the SSD curve system 7 is, however, dominated by system 1, 2 and 3.

THE RISKS WITH REGARD TO NET MARGINS

The slope, intercept and D parameter for each system are as follows:

System	Slope	Intercept	D parameter
1	0,117	0,174	0,588
2	-0,118	0,717	0,264
3	-0,291	1,454	0,238
4	0,707	-2,461	0,201
5	0,146	-0,648	0,297
6	-0,012	-1,350	0,718
7	-0,549	2,115	0,239

The regression lines reveal the same trend as that shown by the yield regression lines. The regression lines of the conventional systems occupy no area above the O axis and must therefore be regarded as relatively inferior. Although system 7 has the greatest negative slope and the greatest positive intercept, it is difficult to make any further deductions with regard to this system with any degree of certainty. It is possible to say though that most of the time systems 3 and 7 maintain the highest expected net margins (performance).

The consolidated figure 4 stresses the relative riskiness of systems 4, 5 and 6 using FSD. No single dominant curve was identifiable in respect of the rest of the systems with FSD. System 3 is dominant in respect of all the systems exept system 7. With SSD though, system 3 is dominant in respect of system 7.

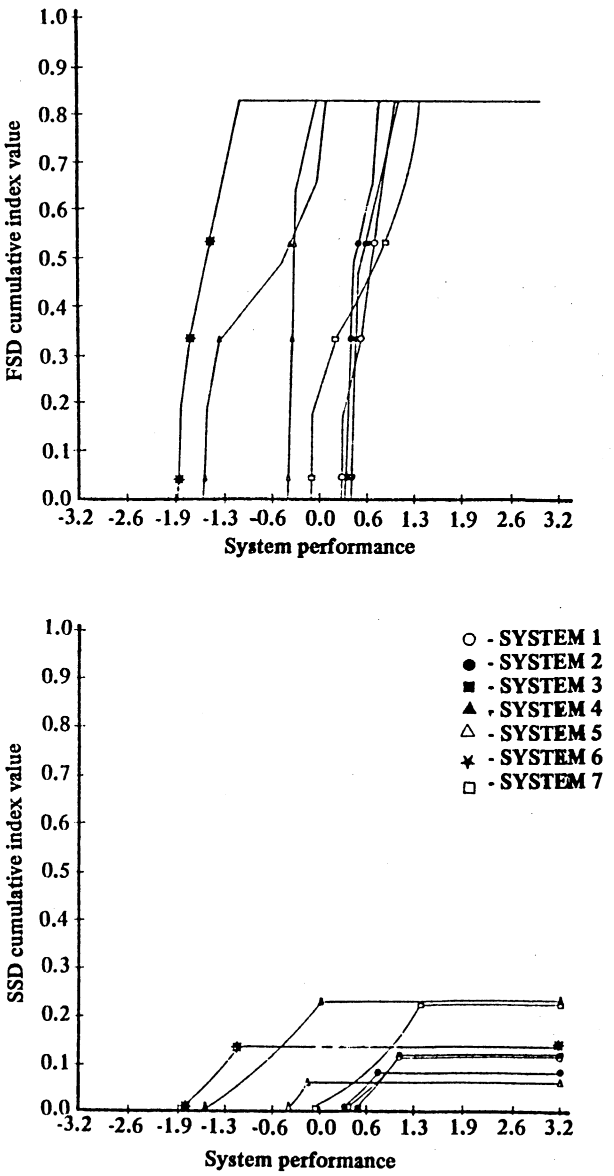
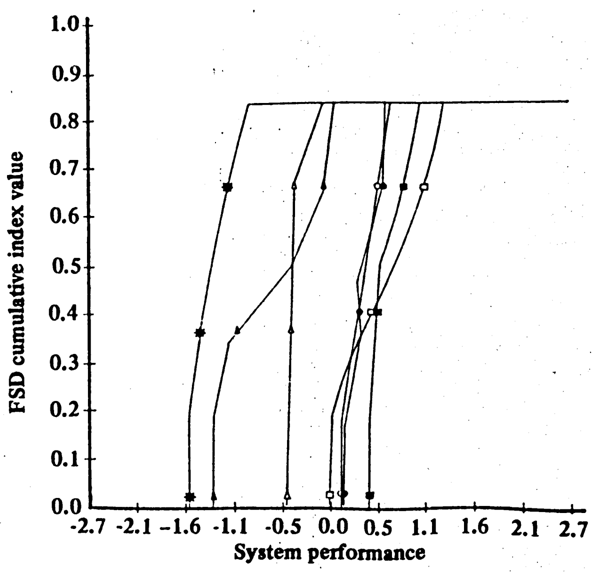


FIG. 3. Consolidation of FSD and SSD in respect of yields



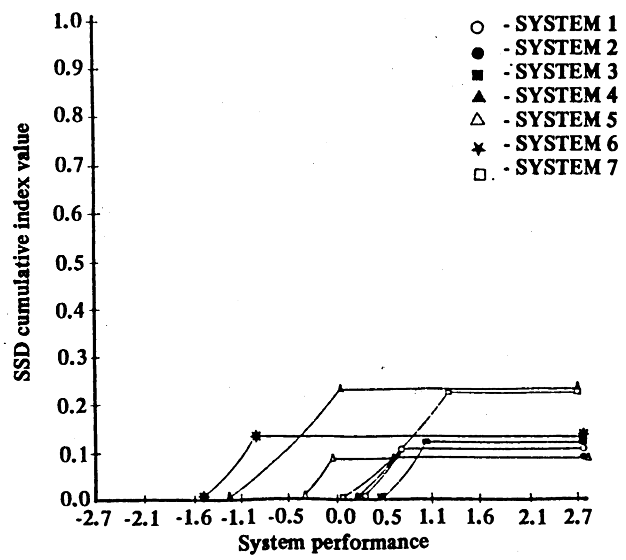


FIG 4. Consolidation of FSD and SSD in respect of net margins

THE RISKS WITH REGARD TO NET MARGINS PER R100 OF CAPITAL INVESTED

System	Slope	Intercept	D parameter
1	0,064	0,177	0,713
2	-0,076	0,796	0,315
3	-0,236	1,962	0,534
4	0,483	-2,523	0,417
5	0,099	-1,333	0,582
6	-0,134	-1,830	0,926
7	-0,466	2,752	0,322

System 4 (winter ploughing) gives the greatest negative intercept followed by system 6 (summer ploughing) and system 5 (deep ploughing).

Therefore, relatively speaking, the conventional systems produce poorer net margins per R100 of capital invested under poor environmental conditions with better

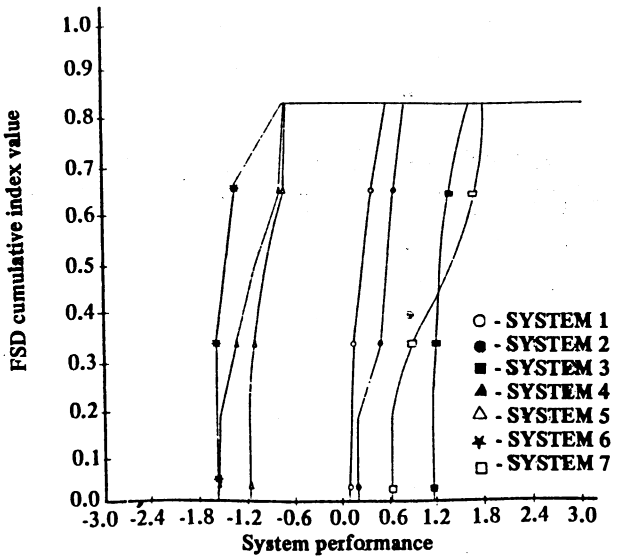


FIG 5. Consolidation of FSD in respect of net margins per R100 of capital invested

prospects under more favourable conditions.

Consolidated figure 5 illustrates once again the riskiness of systems 4, 5 and 6 in respect of FSD. Systems 1 and 2 are also clearly dominated (FSD) by systems 3 and 7. No dominance (FSD) is observable between systems 3 and 7.

The SSD curves (figure 6), however, show dominance of system 3 over system 7. It is therefore clear that system 3 entails the smallest risk.

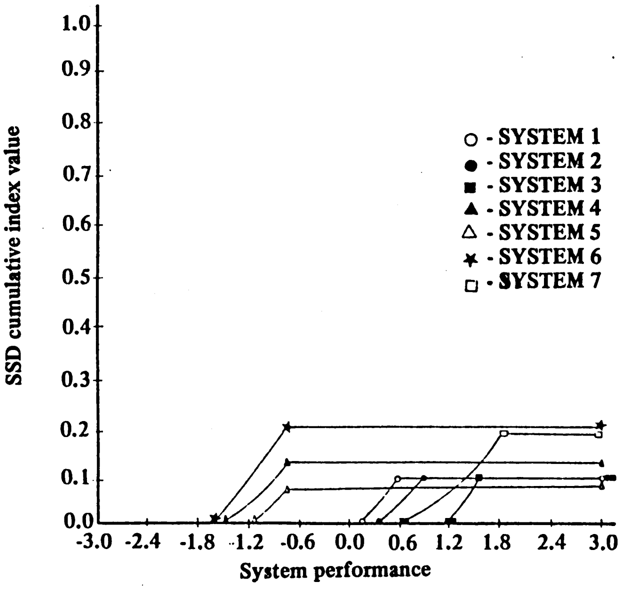


FIG. 6. Consolidation of SSD in respect of net margins per R100 capital invested

SUMMARY

System 6 (summer ploughing) is the most risky system in respect of yields, net margins and net margins per R100 of capital invested.

There are no definite distinctions to be made between systems 1, 2, 3 and 7 as regards yield risks in terms of FSD. With SSD (figure 3) system 7 is dominated by systems 1, 2 and 3.

Systems 3 and 7 (the rip-on-row systems) dominate all the systems as regards net margin risk with FSD, while system 3 dominated system 7 with SSD. The same trend was observed with regard to net margin per R100 of capital invested.

It is therefore possible to state that system 3 dominated all the other systems (with FSD and/or SSD) and that this system must be regarded as the most stable and the least risky.

A further conclusion is that the use of stochastic dominance in risk analysis proved to be a useful differentiation technique in this case.

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