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THE DRYLAND CASH-CROP PRODUCTION POTENTIAL OF NATURAL REGION II

P. IVY

Department of Conservation and Extension, Ministry of Agriculture, Salisbury

THE AGRO-ECOLOGICAL SURVEY of Rhodesia, published over 20 years ago, provides a very good guide to the natural factors governing agricultural production in Rhodesia; and generally the recommended farming systems proposed for the different Natural Areas still hold good today. However, a considerable amount of additional information on rainfall distribution, topography, soil and vegetation types, and, more particularly, crop and livestock performance within the various Regions, is now available to the land-use planner.

Some modification to the Agro-ecological Survey was therefore inevitable and so a revised map, showing slight changes in the delineation of the Natural Regions has recently been produced by the Planning Branch of the Department of Conservation and Extension. This makes use of the rainy pentad analysis developed by Griffith in East Africa which appears to give a better indication of rainfall distribution and its effect on crop yield than does effective rainfall, which was one of the main criteria used in defining the agro-ecological regional boundaries.

A rainy pentad is defined as the centre one of three five-day periods (pentads) which together receive more than 40 mm rainfall and two of which receive at least 8 mm of rainfall. Areas which have the highest crop yields receive on average at least 18 rainy pentads per season, whereas five-year average crop yields of maize, flue-cured tobacco and cotton are generally sub-economic in areas which receive, on average, less than 16 rainy pentads per season. These rainy pentad criteria were therefore used when revising the Agro-ecological Survey map, and the definitions of regions IIa, IIb and III were amended accordingly. The definitions of the Natural Regions now read:

> *Natural Region I: Specialized and Diversified Farming Region:* Rainfall in this region is high (more than 1 000 mm per annum in areas lying below 1 700 m altitude, and more than 900 mm per annum at greater altitudes), normally with some precipitation in all months of the year. Temperatures are normaly comparatively

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low and the rainfall is consequently highly effective enabling afforestation, fruit and intensive livestock production to be practised. In frost-free areas plantation crops such as tea, coffee and macadamia nuts can be grown; where the mean annual rainfall is below 1 400 mm, supplementary irrigation of these plantation crops is required for top yields.

Natural Region II: Intensive Farming Region: Rainfall is confined to summer and is moderately high (750-1 000 mm). Two sub-regions have been defined. Sub-region IIa receives an average of at least 18 rainy pentads per season and normally enjoys reliable conditions, rarely experiencing severe dry spells in summer. The region is suitable for intensive systems of farming based on crops and/or livestock production. Sub-region IIb receives an average of 16-18 rainy pentads per season and is subject either to rather more severe dry spells during the rainy season or to the occurrence of relatively short rainy seasons. In either event, crop yields in certain years will be affected, but not sufficiently frequently to change the overall utilization from intensive systems of farming.

Natural Region III: Semi-Intensive Farming Region: Rainfall in this region is moderate in total amount (650-800mm), but, because much of it is accounted for by infrequent heavy falls and temperatures are generally high, its effectiveness is reduced. This region will receive an average of 14-16 rainy pentads per season. The region is also subject to fairly severe mid-season dry spells and therefore is marginal for maize, tobacco and cotton production, or for enterprises based on crop production alone. The farming systems, in conformity with the natural conditioning factors, should therefore be based on both livestock production (assisted by the production of fodder crops) and cash crops under good mangement on soils of high available moisture potential.

Natural Region IV: Semi-Extensive Farming Region: This region experiences fairly low total rainfall (450-650 mm) and is subject to periodic seasonal droughts and severe dry spells during the rainy season. The rainfall is too low and uncertain for cash cropping except in certain very favourable localities, where limited drought-resistant crops can afford a sideline. The farming system, in accord with natural factors, should be based on livestock production, but it can be intensified to some extent by the growing of drought-resistant fodder crops.

Natural Region V: Extensive Farming Region: The rainfall in this region is too low and erratic for the reliable production of even drought-resistant fodder and grain crops, and farming has to be based on the utilization of the veld alone. The extensive form of cattle ranching or game ranching is the only sound farming system for this region. Included in this region are areas of below 900 m altitude, where the mean rainfall is below 650 mm in the Zambezi Valley and below 600 mm in the Sabi-Limpopo valleys.

This paper indicates the distribution of crop yields by Natural Region, and the work in progress on mapping the major soil types (Natural Areas)

within Natural Regions II and III. Crop yields from as many farms as possible within each soil type are being analysed, so that the yield potential can be more accurately assessed.

FREQUENCY DISTRIBUTION OF CROP YIELDS BY NATURAL REGION

The Farm Management Section, Planning Branch, Department of Conservation and Extension, has compiled and published three editions of a handbook, incorporating the area (Intensive Conservation Area) average yields for all dryland crops from 1963-4 onwards. These yields are the weighted averages, that is, the total production from the area divided by the number of hectares grown.

Five-year average yields from 1970-1 to 1974-5 are given for each Intensive Conservation Area (I.C.A.). The choice of five years was originally made in order to reduce the effect of technological improvements on crop production over a number of years. It does, however, have a disadvantage in that successive five-year averages may vary considerably owing to the effect of sporadic drought years. A longer term average would tend to reduce this variation and there may well be a case in future for the use of a longer period, especially in the case of the major and longer established crops where technological improvement may be expected to be slowing down.

The frequency distribution of maize, flue-cured tobacco and cotton yields by Natural Region are given in Table I which illustrates the high proportion of I.C.A.s in Natural Regions IIb, III, IV and V which obtain average maize yields of less than 4 000 kg/ha. Production of maize at such low yield levels is not economic for commercial sales, but may be justified for the supply of labour rations and stock feed. Practically no dryland flue-cured tobacco or cotton is grown in Natural Region IV and the number of farmers growing these crops in Natural Region III is very limited. Only the more successful farmers have been able to continue growing these crops in Region III, and even then, many are likely to become insolvent at such low yield levels.

This information highlights the need for farming in Natural Region III to be based on livestock production, with dryland cash crop production only under good management on soils of high available moisture potential.

THE MAPPING OF SOIL TYPES

Geological Survey maps and farm plans which cover over 35 per cent of the area were used to map the different soil types in the Karoi, Sinoia and Banket Groups of I.C.A.s. The soils were then classified into groups and subgroups in accordance with Dr. J. G. Thompson's thesis 'The Soils of Rhodesia and Their Classification'.

The mapping units refer to soils occurring on normal or upland relief,

Table 1

FREQUENCY DISTRIBUTION OF CROP YIELDS BY NATURAL REGIONS

FIVE-YEAR AREA (I.C.A. AVERAGE YIELDS (KG/HA))

MAIZE:

Natural Region	*2 000*	*2 000-3 000*	*3 000-4 000*	*4 000-5 000*	*5 000-6 000*	*> 6 000*
I	0	1	1	1	0	0
IIa	0	0	3	8	14	6
IIb	0	2	4	6	0	0
III	8	5	10	2	0	0
IV	14	8	0	0	0	0
V	3	0	0	0	0	0

FLUE-CURED TOBACCO

Natural Region	*1 000*	*1 000-1 100*	*1 100-1 200*	*1 200-1 300*	*1 300-1 400*	*1 400-1 500*	*1 500-1 600*	*> 1 600*
IIa	0	1	2	5	12	8	0	2
IIb	1	0	1	4	3	2	1	0
III	2	1	2	2	3	1	0	0

COTTON

Natural Region	*900*	*900-1 000*	*1 000-1 100*	*1 100-1 200*	*1 200-1 300*	*1 300-1 400*	*1 400-1 500*	*> 1 500*
IIa	0	0	1	3	2	6	2	8
IIb	0	1	2	2	1	0	0	2
III	4	2	4	1	0	2	1	1

and catenary associations are not shown. However, major areas of very undulating to broken country, resulting in a high proportion of lithosols have been mapped. In the description of mapping units, data relating to base saturation, clay mineralogy and E/C value (cation exchange per 100 of clay) refer to subsoil horizons in which the effect of organic matter is negligible. The soil groups and sub-groups occurring within the area covered by this report are:

Calcimorphic Soils:
Unleached soils, generally with large reserves of weatherable minerals; base saturation usually over 80 per cent; clay fractions predominantly 2:1 lattice; E/C values over 40 m.e.

Vertisol Group: Moderately deep to deep, dark self-churning clays; clay fractions mainly montmorillonite; E/C values over 60 m.e.

3X Dark brown to black vertisols without appreciable water soluble salts or exchangeable Na; but generally with inverse Ca/Mg ratios and often with toxic quantities of heavy metals (Ni and/or Cr); formed on ultrabasic rocks.

Sallitic Group: Soils in which the clay fractions are predominantly illite or illite-montmorillonoid mixed-layer minerals: E/C values are usually over 40 m.e.: with or without illuvial calcareous accumulation in the lower solum or underlying material.

4E Shallow to moderately shallow brown or reddish-brown clays; formed on basic rocks.

4S Mainly shallow relatively silty, sandy loams to clay loams; formed mainly on argillaceous sediments.

Kaolinitic Soils:
Moderately to strongly leached soils; clay fractions mainly kaolinite together with appreciable amounts of free sesquioxides of iron and aluminium.

Fersiallitic Group: Soils with appreciable reserves of weatherable minerals; base saturation over 40 per cent, usually between 60 and 80 per cent; clay fraction contain some 2:1 lattice minerals; E/C values range from about 15 to about 40 m.e.

5E Moderately deep to deep, reddish-brown granular clays; formed on basic rocks.

5X Moderately deep clays similar to those of 5E but usually with inverse Ca/Mg ratios and often with toxic quantities of heavy metals (Ni and/or Cr); formed on ultrabasic rocks.

5S Moderately shallow to moderately deep, reddish-brown to greyish-brown, relatively silty clay loams over reddish-brown to yellowish-brown similar clays. The latter are frequently mottled but the soils are not markedly hydromorphic. Formed on argillaceous sediments.

5A Moderately shallow, greyish-brown, relatively silty sandy loams over similar yellowish-brown sandy clay loams; frequently Mottled but not pronouncedly hydromorphic; formed on certain arenaceous sediments.

5F Shallow to moderately shallow, reddish-brown, highly micaceous, fine-grained sandy loams over similar clay loams; formed on highly micaceous materials.

5P Moderately shallow to moderately deep, brown to reddish-brown sandy loams over sandy clay loams; formed on gneisses of various ages and origins.

5G Mainly moderate shallow, greyish-brown, coarse-grained sands throughout the profile, to similar sandy loams over reddish-brown sandy clay loams; formed on granitic rocks.

5M Moderately shallow to deep, greyish-brown sands or loamy sands over light reddish-brown sandy loams; formed mainly on Triassic and, to a lesser extent, Permian formations.

At the scale of mapping of 1:250 000 small pockets of different soil types could not be mapped. Some of the variations will however be mapped at a scale of 1:100 000. No attempt will be made to delineate soil types down to the soil series level.

CROP YIELDS BY SOIL TYPE

The average yields of flue-cured tobacco, maize (long season varieties) and cotton (Albar) from 1971-2 to 1975-6 were calculated for all farms in the three groups of I.C.A.s. The mean crop yields of farms falling predominantly within each soil group were then extracted. Farms containing two or more soil types in approximately equal proportions were excluded from the survey.

Initially, soil groups were further sub-divided acording to variations in parent material, e.g. the granites were subdivided into porphyritic, muscovite and biotite granite, while the gneisses of various ages were split into granitic and sallimanite gneisses etc. It was observed however that crop-yields from farm to farm within a single soil type tended to vary more than mean yields from one soil type to the next. Consequently the crop yields recorded below refer only to the major soil groupings. A set of 1:100 000 maps is however being produced which incorporates the sub-groups.

Because of the very great differences in managerial ability from farm

to farm, average yields for the top third have also been calculated; such yields could be used as a target for crop extension programmes and the assessment of crop production potential.

Maize

Table II illustrates the average and the top third maize yields (mainly S.R.52) from the various soil groups. The top third averages are generally approximately 1 000 kg/ha higher than the overall mean yields.

The top third yields on the granite sands (5G) range from 6 000 to 6 300 kg/ha in the Trelawney and Darwendale I.C.A.s to the south, to 6 800 to 7 200 kg/ha in the Karoi, Doma, and Ayrshire I.C.A.s to the north. Slightly more favourable rainfall distribution might be expected to the north where the influence of the inter-tropical convergence zone is greatest, but differences in altitude are possibly equally important.

Maize yields on the gneisses (5P), arkoses (5A) and epidiorites (4E) range from 6 500 to 6 700 kg/ha, while the lowest yields, 5 800-6 100 kg/ha, are recorded on soils which have a tendency to compaction and sealing of the soil surface. This surface crusting results in poor emergence of seedlings and reduced infiltration of rainfall; on ploughing, large clods are turned up which are not easily broken. The unfavourable characteristics in question are found on the micaschists and phyllites (5F), slates and shales (5S) and metasediments (5SE). These soils have a high content of silt or fine sand and a moderately high clay content.

Flue-cured tobacco

There are a number of factors which must be considered when comparing average tobacco yields from farm to farm, and season to season on the different soil types.

In order to control the availability of soil nitrogen, medium to heavy textured soils are usually ploughed from late July to September, when the soil is dry. This allows little decomposition of organic material before the following rains and consequently more fertilizer nitrogen is required than when the soils are ploughed early. The poorer tilth resulting from late ploughing affects ridging, nematode control and subsequent waterplanting unless these operations are delayed until after the first rains. Tobacco yields are therefore seldom as high as on soils which can be early ploughed. This would account for the top third tobacco yields (see Table III) from the micaschists and phyllites (5F), slates and shales (5S) and metasediments (5SE) ranging from only 1 400 to 1 550 kg/ha, whereas the yields on the granites (5G), gneisses (5S) and arkoses (5A) range from 1 600 to 1 850 kg/ha.

In the warmer, lower altitude areas to the north, many farmers produce an early and a late tobacco crop; the late crop being planted approximately six weeks after the last plantings of the early crop. This delay reduces the overlap in reaping between the two crops and enables the farmers to cope

Table II

MAIZE YIELDS (LONG SEASON VARIETIES)

Soil Type	*I.C.A.*	*Number of Farms*	*Average Yield kg/ha*	*Top Third Yield kg/ha*
5G	Karoi	85	5 474	6 988
	Doma	40	5 683	6 791
	Ayrshire North	23	5 974	7 197
	Ayrshire South	25	5 985	7 022
	Banket and Eldorado	27	5 647	6 783
	Trelawney and Angwa	39	5 104	6 036
	Darwendale	61	5 235	6 331
5P	Karoi	61	5 382	6 666
5F	Karoi	50	4 677	5 787
5S	Angwa	27	4 758	5 902
5A	Angwa	44	5 420	6 515
5M	Angwa	26	5 620	6 972
5SE	Angwa and Eldorado	27	5 132	6 146
4E	Banket	14	5 620	6 563

with an increased area under tobacco without engaging extra labour or increasing the curing facilities. The late crop does, however, have a significantly lower yield potential. Crop yields obtained from the Central Statistical Office give no indication of the proportion of early to late plantings.

In the warmer lower altitude areas, leaf ripening rates are generally much faster than at higher altitudes, and so a narrower hectares per barn ratio is required in such areas to reduce leaf losses in the field during periods of peak leaf ripening. It is possible that the higher yields obtained in the

Darwendale area are the result of more favourable ratios of early to late plantings and hectares planted per barn. This requires further investigation.

Erratic or sub-economic yields have caused many farmers to give up tobacco production on the less suitable soil types, with only the more efficient farmers continuing to grow tobacco.This feature is reflected in the low number of tobacco farmers in the slates, arkoses, metasediments, (5S and 5SE) and dolomites, which in the mid 1950s would have equalled the number of maize farmers on these soils today.

Table III

FLUE-CURED TOBACCO YIELDS

Soil type	*Area*	*Number of Farms*	*Average Yield kg/ha*	*Top Third Yield kg/ha*
	Karoi	83	1386	1698
5G	Doma	33	1399	1659
	Ayrshire North	25	1277	1675
	Ayrshire South	20	1503	1764
	Banket and Eldorado	21	1354	1581
	Trelawney and Angwa South	41	1375	1665
	Darwendale	58	1494	1845
5P	Karoi	52	1334	1699
5F	Karoi	42	1181	1458
5S	Angwa	4	1284	1554
5A	Angwa	18	1306	1718
5M	Angwa	11	1207	1474
5SE	Angwa and Eldorado	8	1156	1383

Cotton:

Well drained sandy clay loam or heavier fertile soils, but without excessive soil nitrogen, are best for cotton production. Soils lighter than sandy clay loam are not generally recommended. Drainage is more important than soil depth which, however, should be not less than 0,6 to 0,9 m.

Mean minima temperatures should not generally be less than 15°C for prolonged periods. The lower temperatures prevailing at altitudes in excess of about 1 200 m are at present unsuitable for cotton growing.

Practically the whole of the Karoi group of I.C.A.s and the Darwendale, Trelawney and Banket I.C.A.s are unsuitable for cotton production on account of the cool climatic conditions and the light textured soils.

Apart from the cotton produced on the metasediments (5SE) in the Eldorado area, there are insufficient farms on which cotton is grown on the other soil types for a retiable estimate of yield potential to be obtained from the figures given in Table IV.

Table IV

COTTON YIELDS

Soil type		*Number of Farms*	*Average Yield kg/ha*	*Top Third Yield kg/ha*
5G*	Doma	10	1 410	1 941
5A	Angwa	8	1 321	1 497
5S	Angwa	7	1 166	1 769
5E/M	Angwa and Doma	8	1 281	1 560
5SE	Eldorado	23	1 415	1 793
4E	Banket	3	1 367	1 872

*The granites on which cotton is grown in the Doma I.C.A. are all contaminated, giving rise to sandy loam to sandy clay loam soils.

CROP PRODUCTION POTENTIAL: KAROI GROUP OF I.C.A.s

Land Capability Classification: Over 40 per cent of the farms in the Karoi area have been planned. Many of the farms, however, were planned before the date when the land capability classification criteria were modified to allow for the inclusion of moderately shallow (0,50-1,00 m) sands on 2-5 per cent slopes into Class III. Previously such soils were placed in Class IV. Using the present land class criteria, the percentage of Class III land would

be higher than that recorded in Table V, and the percentage of Class IV correspondingly lower.

Table V

PERCENTAGES OF EACH CLASS OF LAND WITHIN THE MAJOR SOIL TYPES

Soil type	*Total Area (ha)*	*Arable Land Classes*				*Vleis*	*Non-Arable*	
		II	*III*	*IV*	*V*	*VI*	*VII*	*VIII*
5G	92 000	6	35	26	24	7	2	0
5P	132 000	9	28	26	26	9	2	0
5F	82 000	16	27	12	15	20	9	1
5F/2	96 000	Litholsols, mainly classes V, VI and VIII.						
5P/2	13 000							
TOTAL	415 000							

Net Arable Area: The land capability classification gives an inflated assessment of the amount of land available for crop production: 25 per cent must normally be deducted from the arable area recorded on the land class map to allow for land lost in 'squaring off' lands, areas for homesteads, road reservations, headlands, inaccessible pockets of arable land, marginal soil areas, etc. A further 10-25 per cent must be deducted from the area of arable lands to cater for land taken up by contours, access roads within the lands, artificial grass waterways and anthills. The steeper the land, the narrower is the horizontal interval between contours (thus 10 per cent must be deducted from the gross arable area where the slope is 0-2 per cent; 15 per cent where 2-5 per cent; 20 per cent where 5-8 per cent; and 25 per cent where 8-12 per cent.) In the Karoi area the land slopes generally range from 2-5 per cent.

Table VI

NET ARABLE AREA

Soil Type	*Total ha*	*Land Class Arable*		*Gross Area of Lands (ha)*	*Net Arable Area (ha)*
		%	*ha*		
5G	92 000	67	61 640	46 230	39 295
5F	132 000	63	83 160	62 370	53 015
5P	82 000	55	45 100	33 825	28 750

Note: Land class area less 25 per cent = gross area of lands, less 15 per cent = net arable land.

Crop Rotation: In arriving at what are considered reasonably safe and tolerable crop rotations, cognisance has been taken of the amount of soil lost from arable lands within the rotation cycle. There is evidence to prove, for example, that soil loss from second and third-year tobacco on sandveld is significantly higher than soil loss from first-year crops.

Table VII

RECOMMENDED CROP ROTATIONS FOR NATURAL REGIONS II and III

Soil Type	*Slope %*	*Land Class*	*% Crop in Rotation*
Sands, with or without heavier textured subsoils	0 — 2	II and III	100
		IV	50
	2 — 5	III	50
		IV	33
	5 — 8	IV	25
Sandy loam to sandy clay loams	0 — 2	II and III	100
		IV	50
	2 — 5	II	66
		III	50
		IV	33
	5 — 8	III	33
		IV	25
	8 — 12	IV	25
Clay loam to heavy clays	0 — 5	I and II	100
	5 — 8	III and IV	50
	8 — 12	IV	33
Marginal vlei soils	0 — 5	IVw	50

With the 50 per cent to 100 per cent crop rotations at least half the crops grown should be capable of providing an adeaquate cover early in the season, as maize does. Crops such as cotton, tobacco, and late planted legumes have a high erosion risk and should not be grown too frequently in the rotation.

On 0-2 per cent slopes there are no restrictions on land use except that farming operations should normally be carried out on the contour.

Where there are contour ridges, crop ridges may be at 90° to the contour. No special rotational requirements are specified other than those necessary for cultural considerations, such as eelworm-suppressing grasses grown in rotation with tobacco. Examples of recommended rotations would be:

100	per cent crop rotation:	Continuous maize or maize/cotton rotation.
66	„ „ „ „ :	Three cycles of a maize/cotton rotation followed by three years' grass.
50	„ „ „ „ :	Maize/Soyas/Maize/three years' grass ley.
	or	Tobacco/Maize/Maize/three years, grass ley.
33	„ „ „ „ :	Tobacco/Maize/four years' grass ley
	or	Cotton/Soyas/four years' grass ley.
25	„ „ „ „ :	Tobacco/three years' grass ley.

Annual Cropping Areas: The net annual cropping area is obtained by applying the recommended crop rotation for the soil type to the net arable area.

Soil groups 5G and 5P are predominantly sands, with or without heavier texture subsoils, on slopes of 2-5 per cent, usually falling into land Class III. Thus a 50 per cent cash crop rotation such as three years' cash cropping followed by three years' established grass ley would normally be recommended for these soils. Flue-cured tobacco production is however the most profitable enterprise in the area, and therefore to maximize tobacco production, a tobacco, maize, three-year ley rotation would be better in an uncontrolled export market situation. The soils in group 5F, are predominantly sandy loams to sandy clay loams with heavier subsoils. Where surface crusting is severe the land is down graded to Class III. Recommended crop rotations are continuous maize on land slopes not exceeding 2 per cent, and tobacco, maize, three years' grass ley or three years' maize, three years' grass ley on land slopes of 2-5 per cent.

Table VIII

CROP PRODUCTION POTENTIAL, KAROI GROUP OF I.C.A.s

Soil Type	*Net Arable*	*Rotation*	*Tobacco*		*Maize*	
			ha	*Potential Yield (tonnes)*	*ha*	*Potential Yield (tonnes)*
5G	39 295	T.M./GGG	7 860	13 346	7 860	54 926
5P	53 015	T.M./GGG	10 600	18 009	10 600	70 660
5F	28 750	T.M.M./GGG	4 790	6 984	9 580	55 439

SUMMARY

This paper outlines the work currently in progress on the mapping of the major soil groups within the intensive farming regions, and the calculation of crop yields by soil type. The arable land percentage for each soil type will be assessed from an analysis of farm plans. Based on sound crop rotation practices, the annual cropping areas and crop yield potential will be estimated for each group of I.C.A.s within Natural Region II.

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