LAND USE PLANNING FOR SUGARCANE

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Abstract

The steps taken in land use planning are explained, using some completed farm plans as examples. Field layouts before and after planning are compared in terms of possible machine efficiencies. Soil protection and agronomic advantages are discussed. An attempt is made to estimate the cost of the operations involved, in order to highlight the advantages of a new layout. The problems of implementing a new plan and methods used to establish a work programme for five years or more are given.

Introduction

In order to obtain maximum economic crop production it is necessary to relate agronomic practices and mechanization to the climate and the soil and topography of a farm unit. The optimum cane yields obtainable on different soil types and from different land use classes are seldom the same. Strong, deep dolerite soil will have a better potential for crop growth than a shallow granite soil. Valley bottom areas with deep wet soils produce more cane than areas of shallow soil on hilltops. The sugarcane grower has to recognise that different parts of his farm require different types of management and he must integrate these into a balanced working plan, whereby each unit of land produces its economically optimum yield. With all the variables in sugarcane growing to consider, it is essential to follow a prepared plan for at least five years so that a balanced operation can be achieved.

Steps in Farm Planning

The four main steps involved in the preparation of a farm plan are :

1. Complete farm assessment.
2. Setting objectives and targets.
3. Final physical plan.
4. Implementation programme.

When these steps are followed, the result is a working plan which obviates the need for random decisions on the timing and nature of field operations. Sufficient flexibility exists in the plan to allow for some changes to be made. Climatic variations from season to season will affect the amount of cane to be cut each year, but this should not be allowed to affect the percentage of the area programmed for cutting.

Assessment

The first stage in any planning work should be to establish as accurately as possible the resources available for crop production. Some of the means by which this can be accomplished are described below :

Initial Planning Tools

Aerial photography. Aerial photographs can be used to provide a three dimensional assessment of the farm. The whole of the sugarcane industry has been photographed from a flying altitude of 4 600 m. With the camera focal length of 150 mm this gave a scale of 1:30 000 for contact prints. Enlargements of these to an approximate scale of 1:6 000 gave photographs which have good definition for use in the identification of fields, streams and objects on the ground (Figure 1). Identification of soil type boundaries, rocky outcrops, wet areas and other items can also be done. Because of distortions within these photographs they cannot be used for measuring exact areas, road lengths or slopes.

Form line maps. Stereoscopic models are prepared from the aerial photographs. All distortions occurring in individual photographs can be eliminated by these means. Stereoscopic interpretation permits lines of equal elevation at 10 m vertical intervals (form lines) to be drawn. These are true to scale and represent specific elevations in relation to known reference points Converging form lines indicate that slopes are increasing in steepness, diverging form lines indicate that slopes are decreasing in steepness. Form line maps permit an interpretation to be made of the topography, and they can be used to establish where crest and drainage lines occur.

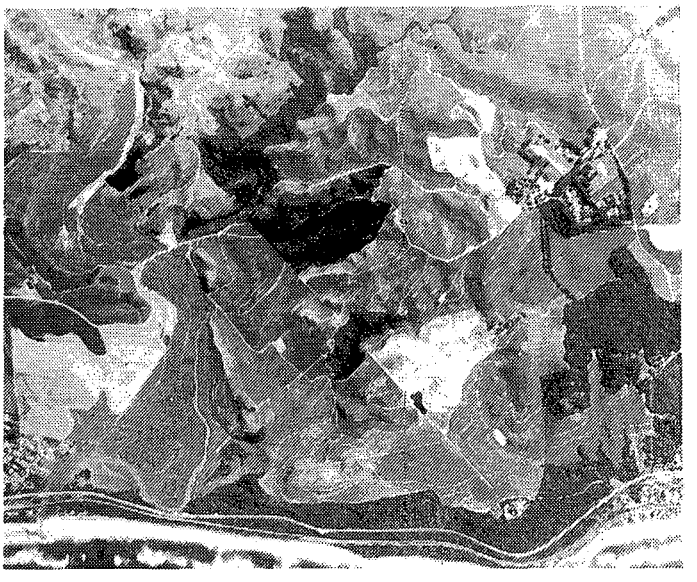

FIGURE 1 Aerial photograph of a coastal sugarcane farm.

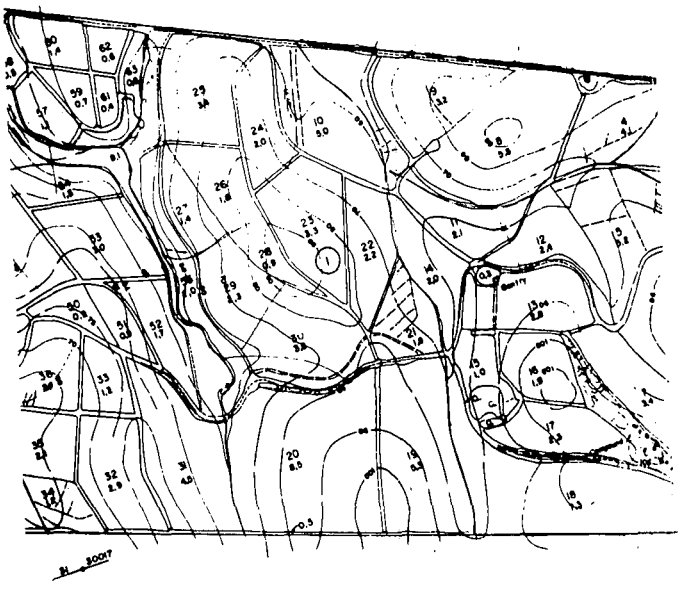

FIGURE 2 Portion of a form line development map, showing field boundaries and form lines.

The initial layout of each field can be planned on the form line map and the plan can be checked later in the field.

Quota maps. Produced from aerial photographs, these maps at a scale of 1:6 000 show field boundaries, cane breaks and other physical features recognisable from the photographs. They are true to scale with field numbers and sizes shown, and they can be used to show field details such as ratoon number and the age of the crop.

Form line development maps. The combination of the form line map and the quota map, both true to scale, gives a map from which slopes and topography changes can be measured for individual fields. The positions of roads can be checked and modified if necessary to follow gradients which are suitable for crop extraction and other purposes. This type of map, although a true plan, does lack the visual appeal of the photograph.

Orthophotography. By using sophisticated cameras and other equipment it is possible to scan a stereoscopic model and to produce an orthophotograph which for all practical purposes is free of distortion. By printing or scribing form lines or contours onto the photograph an orthomap is produced which has the visual appearance of the photograph but is also true to scale.

The Initial Plan

When a request for a Land Use Plan is received, a photograph, a set of form lines, a quota map and a form line development map are prepared for use in the first assessment. An industry wide soil survey, (Beater [1, 2, 3]) provides the soil parent materials for each farm. The areas under sugarcane are drawn onto the form line development map and a layout with graded terraces, waterways and roads is designed to suit both the soil and the topography. If the areas of valley bottoms, hillside slopes and flat crests are large enough to warrant it, then they are each given separate consideration in the plan. Steep hillsides might be suitable for minimum tillage and strip cropping. Crop extraction routes to suitable loading zones, possible stream crossings and diagonal roads can also be planned with the aid of stereoscopic photograph interpretation. As work proceeds a list of items to be checked in the field is compiled.

Farm Visit

The initial plan prepared in the office is taken to the farm for checking. The grower's individual preferences, his methods of operation and the type of equipment that he uses, together with all field details, are recorded here.

Grower preferences. At the first meeting with the grower the development of the plan is discussed. The preferences expressed by the grower for particular methods of operation or layout are drafted into the plan after confirmation that they are compatible with the topography of the farm. If the farm has been divided into different categories of land, these are examined. Changes in soil type from valley bottom to hillside and to crest area may help to determine where field boundaries should be. Operational methods and the inventory of farm equipment are fully discussed.

Field details. Each field is examined and details of the ratoon number, crop age, growth stage and, if possible, the previous history of the field are recorded. Generally the estimate book contains most of these details but sometimes it is necessary to visit each field and to estimate the crop status on the site.

Cutting programme. The order in which the fields have been cut or are due to be cut is noted. When the field details have been recorded, the order of areas to be ploughed out annually is determined and the amount of cane to be delivered daily is noted.

The ploughing out programme. The order in which the grower intends to re-establish fields is recorded, as well as any specific reason for ploughing out a field, such as disease, low yield or wish to change cane variety. The total area which a grower feels capable of replanting, and the rate at which he is able to achieve this, are noted because they might have a bearing on future replanting programmes.

Problem areas. Specific problems such as drainage, rock outcrops, and permanent roads, pipelines and powerlines, are marked on the map for future reference. Loading zones and cane extraction routes are often fixed, but the possibility of changing zones, sidings or exit points should be discussed as they could play a role in reducing transport costs.

Analysis of the Records

The object of this exercise is to see if the farm operations are balanced. Using past performances as a guide, realistic objectives can be set. From the records the percentage area of each ratoon on the farm can be established and the average age of each ratoon stage can be calculated. Once the average

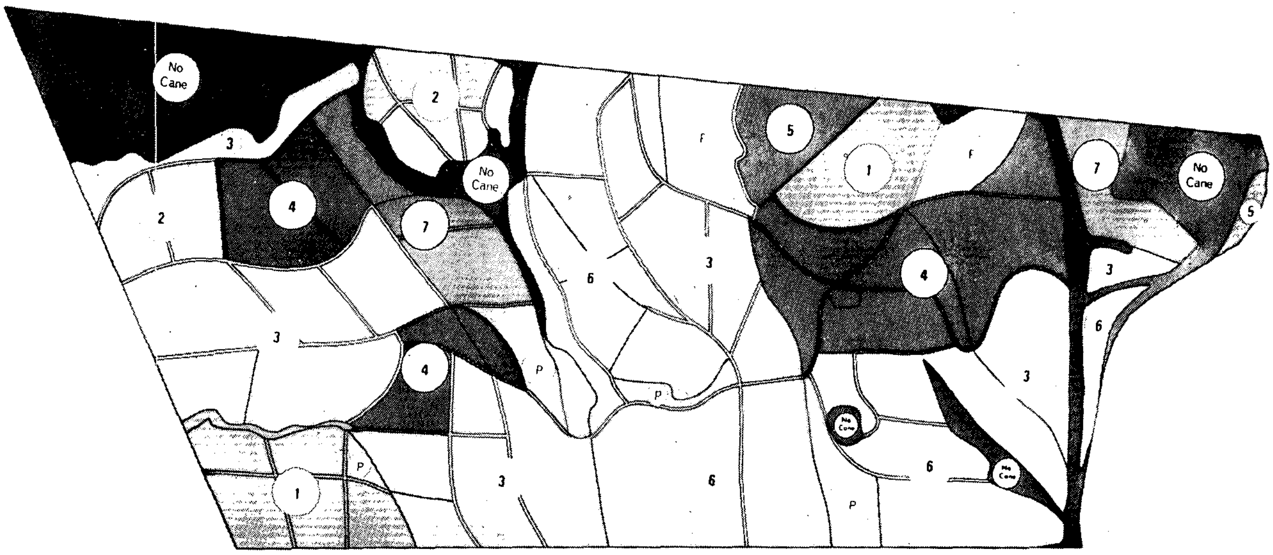

FIGURE 3 Identification of existing crops on farm (A), where P = plant and I = first ratoon.

cutting age is known, an indication of the proportion of each ratoon stage can be obtained. If the farm is badly out of balance, there will be an uneven distribution of areas of the different ratoon stages.

The percentage of the crop cut during a season is inversely proportional to the average age of cutting. If there is no fallow land on a farm with 200 ha of cane and the average cutting age is 18 months, then two thirds or 133 ha will be cut annually. An analysis of the records can show whether the area harvested during one season is proportional to the average age of cane at the time of harvest. If the figures are not approximately proportional then an imbalance will occur again in the following season.

The area to be ploughed out annually can be determined from the average age of cutting and the average number of ratoons obtained. (On a 200 ha cane farm where an average of seven crops having an average age of 17 months is obtained, and four months are needed to re-establish the crop, a ten year crop cycle occurs, ie the whole of the 200 ha will be re-established in just over ten years, or 10% per year). Careful examination of past production figures generally indicates which fields should be the next to be replanted.

Setting Objectives

Once the performance of a farm has been analysed and major areas for improvement have been determined, objectives can be set. The *extent* of each type of production area must be measured and the *optimum age* of cutting the crop on the individual areas must be decided upon. An estimate is then made of *how many crops* can be expected from each area. As an example, on farm (A) near Empangeni the soils were generally uniform and the area could be divided simply into valley bottoms (41 ha), hillsides (107 ha) and hilltops (73 ha). As few farm records were available assessments were made using rainfall data and the yields obtained on neighbouring farms. The result was a plan to cut the crop on average every 17 months, and to obtain seven crops on the hillsides and hilltops, resulting in a cycle of just over ten years. Since the area comprising these categories was 180 ha, about 18 ha would have to be replanted annually. In the valley bottom areas, where drainage was required, the cane would be cut at an average age of 14 months. Aiming again for seven crops, a cycle of just under nine years would be obtained and an annual ploughout of approximately 5 ha would be necessary. The annual ploughout for the whole farm was therefore 23 ha.

Final Physical Plan

After taking cognizance of the growers' preferences and also of particular features observed in the field, the final plan can be draughted (Figure 4). Before it can be accepted, however, it must be compared with the original layout to see if it represents a real improvement. Transport and infield work are two major items in cane farming operations which need to be considered in this respect. The effects of improved soil protection and any change in the area under cane must also be assessed.

Transport Efficiency

Using the quota map which shows the field areas and boundaries, the likely yield to be obtained from each field must be set. Cane row alignment within each field can be drawn on the map. The distance along the cane row from the centre of the field to the nearest road, added to the distance measured along the most practical route to the loading zone, provides an estimate of the average haulage distance from the field. Multiplying estimated yield by this distance gives an estimate of the transport requirement in ton-kilometres. The sum of these products for all fields gives an indication of the total work to be done in moving the crop. When this exercise is carried out for both the old and the new layouts, a comparison such as that shown in Table 1 for farm (A) can be made.

In this instance only a relatively small saving in distances was achieved, but most of the crop movement using the new layout occurred along fairly level roads. The same exercise was carried out for two other farms (B and C) where no re-siting of the loading zone was possible, and for a further farm (D) where the loading zone was re-sited specifically

TABLE 1

The total transport requirements for four farms expressed in ton-kilometres

Layout	Farm A	Farm B	Farm C	Farm D
Old	11 303	13 296	20 748	24 377
New	10 925	13 047	15 687	15 845
Improvement . . .	3,3%	2,0%	24,4%	35,0%

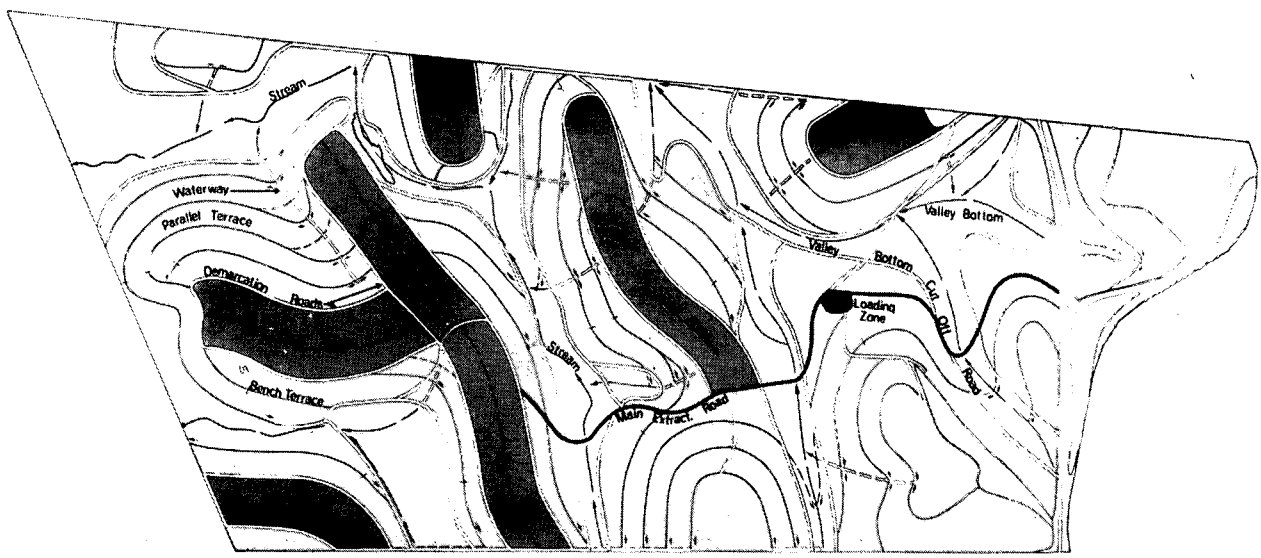

FIGURE 4 The partitioning of farm (A) into valley bottoms, hillsides and crest areas to form the proposed plan.

so that transport costs on the farm would be as low as possible. The results are also given in Table 1.

Infield Machine Efficiency

The time spent by machines in the field on productive work as a proportion of total time (including turning time) gives an index of machine efficiency for any field. This ratio is called the Field Machine Index.

$$FMI = \frac{Pt}{Pt + Tt}, \text{ where } Pt = \text{production time}, \; Tt = \text{turning time}$$

For a constant field area, the FMI increases as the average row length increases and this can be effected by changing the shape of the field. Irregularly shaped fields generally cause the FMI to be lower than it would be in fields laid out on the contour, and having fairly long, approximately parallel sides. Table 2 shows the data for the four farms (A, B, C & D) mentioned as examples previously.

TABLE 2
Average estimated Field Machine Indices for four farms

Layout	Farm A	Farm B	Farm C	Farm D
Old	0,53	0,62	0,70	0,59
New	0,71	0,70	0,82	0,69
Improvement . . .	34,2%	13,0%	17,0%	16,9%

Changes in Soil Loss

A soil survey was carried out on farm (A) to confirm the identification of soil parent materials, and to look closely at surface soil textures and soil depths. Using the information obtained, comparisons of expected soil losses from the farm before and after planning were made by means of the Universal Soil Loss Equation (Wischmeier and Smith[5]). Estimates were made of the main slope gradient and slope length. It was assumed the value of the factor P (for field practice) was 1,0 for all fields prior to planning. The soil losses from each field were calculated (see Figure 5) and summated for the whole farm.

The same exercise was carried out for the proposed layout. The value of factor P was changed to 0,7 to allow for the effects of the proposed terraces. The results for both layouts in terms of average expected soil life appear in Figure 6.

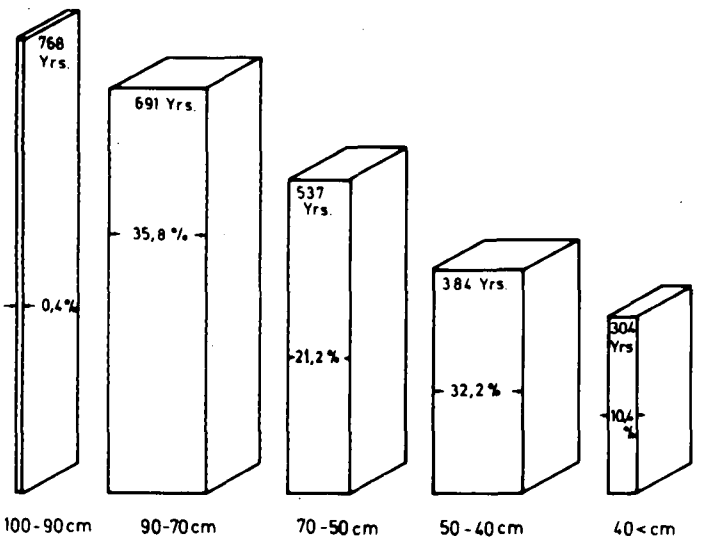

FIGURE 5 Percentage of soil depth classes with their predicted soil lives for the existing layout of farm (A).

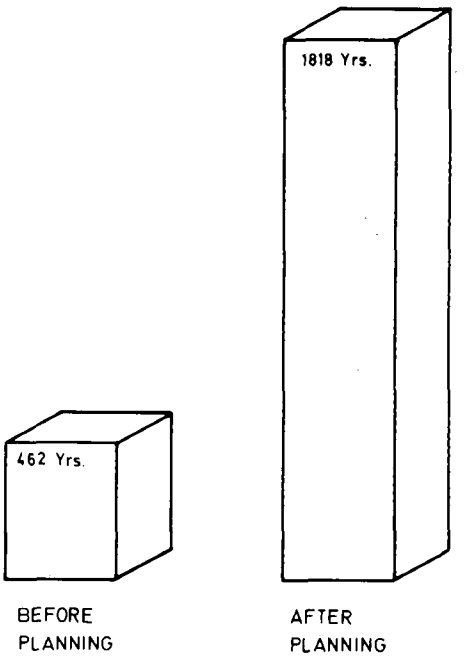

FIGURE 6 Average predicted soil life before and after planning farm (A).

Roads, Waterways and Breaks

In most cases planned layouts have larger areas occupied by roads and structures than do unplanned layouts. This results in cane land being lost from production and the loss has to be offset against the benefits due to the new layout. An assessment for farm (A) in terms of cost is shown in Table 3.

TABLE 3
Economic implications of a new layout on farm (A), R/annum

Additional income		Expenses incurred	
Transport 3,34% decrease at 7 c/t km	= R 27	Terraces 2 960 m at R10/100m	= R296
		Waterways 0,14 ha at R300/ha	= R 42
		Loss in revenue 0,98 ha at R270/ha	= R 265
FMI 34% improvement 190 ha at R23,80/ha	= R4 522	Maintenance 2 600 m at R8/100 m	= R 208
		Total	= R 811
		Balancing item SAVING	= R3 738
TOTAL . . .	= R4 549		= R4 549

Implementation

The means by which field boundaries and ratoon distribution were changed on farm (A) are described here as an example. As the hillsides and crest areas were very similar for crop production, they were combined for setting the objectives.

The plan of the existing distribution of ratoons (Figure 3) was taken and overlain with a transparent print of the proposed plan (Figure 4). Using ratoon number as the main guide, a grouping of fields for ploughing out was determined. Where necessary, changes in cutting times were made to ensure that as little disruption as possible occurred in the

TABLE 4

The programme of work to be done and an estimate of the costs to be incurred in implementing a new farm plan

	1979	1980	1981	1982	1983	1984	1985	1986	1987
Terraces (metres) .	1 292	3 348	2 060	1 966	1 796	1 414	898	1 246	908
Roads (metres) . .	1 830	570	1 260	1 630	930	1 686	0	1 930	640
Waterways (metres) .	130	452	910	18	168	72	0	0	25
Hectares to plant .	17,5	26,0	22,2	18,9	24,8	18,9	15,7	19,9	20,1
% of farm replanted .	9,5	14,1	12,1	10,3	13,5	10,3	8,5	10,8	10,9
Annual Cost in R . (structures)	R339,20	R484,80	R518,00	R377,60	R296,60	R325,00	R217,60	R317,60	R160,80

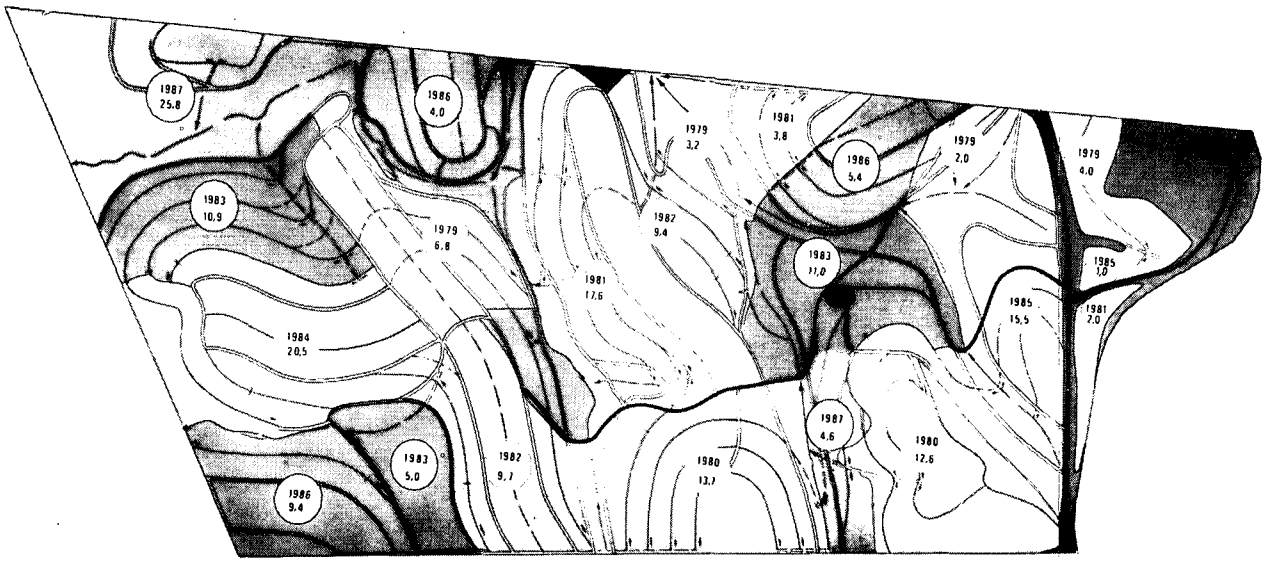

FIGURE 7 An indication of the means by which a farm plan can be implemented over a nine-year period on farm (A).

existing schedule. The implications of the proposed ploughing out programme can be seen in Figure 7.

Table 4 shows a nine year programme by means of which the feasibility of the exercise could be checked. For practical reasons, at least a five year programme should be used. Certain adjustments will always be necessary, but these should take place within the framework of the plan.

Conclusions

A step by step approach to the preparation of a farm plan permits improvements to be made to most farming operations. It is considered necessary to set objectives for at least a five year period so that balanced harvesting and ploughing out programmes can be achieved. It is appreciated that seasonal changes can cause production to vary from year to year, but this should not be reason to change the percentage of the area to be harvested. Fields may be selected for ploughing out by a number of methods, depending on particular circumstances. Whatever method is used, targets must be set and, as management of the crop improves, the objectives can be re-evaluated.

Improved transport and field efficiencies have been shown to occur after the implementation of new farm plans. Other advantages, not so easily defined, also occur. These include better water utilization, less infield traffic and soil compaction, easier management, greater accessibility and better fire control.

Improvements due to programme planning can be achieved using the existing farm layout (Thompson and Moberly[4]). If the layout system is improved, the advantages of programme planning may also increase because of the improvements in operating efficiencies.

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