THE PASTURE PROSPECT IN THE HUMID GRASSLANDS OF SOUTH AFRICA

P. de V. BOOYSEN

Associate Professor, Department of Pasture Science, University of Natal, Republic of South Africa

INTRODUCTION

IT WAS my original intention to present a review of past and present pasture research work in South Africa and to speculate on future developments in pasture production and research. For a variety of reasons I have limited myself to a consideration of the present and future pasture practices and problems in the humid grasslands of South Africa. Perhaps the primary reasons for the narrower scope of my paper are, first, that space and time do not permit a complete review of the pasture scene in all the varied ecological regions of South Africa and, secondly, that very excellent reviews of this nature have recently been published. At the inaugural congress of the Grassland Society of Southern Africa, Tidmarsh (1966) outlined the present state of pasture research in South Africa and offered some thoughts on future pasture developments. Soon afterwards, Scott (1967a, b) published a detailed review of past pasture research work in South Africa. With these papers providing the background, I can safely confine my discussion to a consideration of current trends and future developments. Furthermore, because my interest lies in the humid grasslands of South Africa and because it is these areas which would hold most interest for the pasture scientist of New Zealand, I will limit myself to a consideration of the summer rainfall zones of South Africa with an average annual rainfall in excess of 30 in. (areas 2 and 3 on the rainfall map presented by Scott (1967b)).

THE PRESENT PASTURE SCENE

The high rainfall grasslands of South Africa occur primarily east of the Drakensberg escarpment. While the climatic climax vegetation is some form of woodland, varying from a patchy bush clump savannah in the drier regions to a closed forest in the higher rainfall areas, the predominant scene is one of open natural grassland (grass-veld) maintained as a sub-climax by fire. These perennial grasslands are mixed in species composition and provide a dense cover to the. soil. The average annual yields from these natural pastures vary from one to two tons of hay per acre produced in the summer months. Generally it can be said that the limiting factor to summer production in these areas is not moisture but soil fertility and/or the genetic constitution of the component species. Primarily low moisture but also 'low temperatures prevent growth in the sub-tropical species during the winter months.

For the most part, the humid grasslands are being farmed semi-extensively and certainly far more extensively than they could be if the available moisture is any indication of potential production and intensification. Most farms would fall into the 1,000 to 5,000 acres size category. An average 2,000 acre farm would have little more than 10% under the plough for annual cropping or under improved pasture established by conventional means involving seedbed preparation and sowing of improved and often imported strains of grasses and legumes. The areas selected for cultivation are generally the bottomlands and. the gentler slopes in a region with topography varying from undulating to steep and rugged. High yields are obtained from these arable areas with high levels of liming and phosphatic, nitrogenous and, sometimes, potassic fertilization. Yield objectives of 10 tons of hay per acre per annum are not unrealistic. The basic pattern of management is the utilization by grazing of the natural grasslands in summer and fodder conservation on the arable areas for winter feeding when the natural grasslands are unpalatable or, in local parlance, "sour". Often cultivated pastures are used as grazing in both summer and winter, particularly when milk production is involved.

Grazing management of the veld is also generally of a very extensive type.. varying from continuous grazing to rotational resting and grazing, on seldom more than a four or five paddock basis. Continuous grazing has always been associated with bad management because of the markedly selective manner in which these mixed grasslands are grazed. The sward may consist of anything up to 50 component grass species representing a wide range in acceptability to the animal. The rotational use of the veld is widely advocated and applied in order to achieve a more 'even utilization by means of higher stocking densities 'and therefore to minimize the harmful effects of selective grazing. To what extent the somewhat extensive forms of rotation, and the methods of rotation employed, have achieved the objective is doubtful. The intensity of the rotational system (the number of paddocks per group of animals) and the desired degree of utilization to be achieved are very controversial issues in veld management thinking at present and will be discussed later. Grazing management of the sown pastures is based on the same pattern as that for the veld, the underlying objective being the reduction of selective grazing with little thought given to such important matters as optimum levels of utilization, the length of the periods of stay and, absence, and the maximization of production. These matters, too, will be discussed presently.

THE PASTURE PROSPECTIVE

There can be little doubt that the extensive methods of utilization employed in the high rainfall grassland areas of South Africa and the resultant relatively low level of production per acre are due primarily to a lack of economic pressure on the land to produce human food. The economic demand for human food is adequately met; in fact, annual food surpluses, notably grain and sugar, are usually experienced. Under these conditions, the selling price of the product to the farmer offers little incentive to intensification toward maximal production on all the land. And so the pattern of intensification and high production on selected sites only and extensive utilization of the remaining areas continues to be the rule in these regions.

Equally, there can be little doubt that this pattern of low production farming will change. As in all parts of the world, South Africa is experiencing its own population explosion. Increasing population alone will in the near future place increasing demands on agriculture for human food. But in South Africa the situation is compounded, by a rapidly rising standard of living of the developing races which constitute about four-fifths of the total population. Thus, in spite of the fact that South Africa still today exports a considerable amount of agricultural produce, it must be expected that in the future population expansion and the rapidly rising standard of living of the masses will soon make the demand for foodstuffs greater than the supply. At this stage it will become imperative that agricultural production is intensified to meet this demand and the price structure of agricultural products will change so that incentive for increased production is provided to the farmer.

It is suggested that seven degrees of intensification of pasture farming and pasture management can be recognized. Production per acre increases progressively with each. step in intensification. While the environmental conditions in any area will determine the degree of intensification permissible, economic factors of the system will dictate whether any increase in intensification is justifiable. The degrees of intensification may be listed as follows: (i) Natural pastures, continuously grazed at stocking. rates below the carrying capacity (pioneer farming), (ii) Natural pastures,' continuously grazed to capacity, (iii) Natural pastures, rotationally grazed and rested, (iv) Natural pastures, rotationally managed and supplemented by sown pasture, (v) Improved grass/legume pastures, rotationally managed, (vi) Improved grass pasture with nitrogenous fertilizer, rotationally managed, (vii) Improved grass pasture with nitrogen, zero grazed. In the arid and semi-arid areas of the country where wool and beef are the main products the farming systems applied (categories (i) to (iv) above) are already up to the level of intensification dictated by the environment. In fact' in some areas, such as the wool producing Karoo (dwarf shrub) region it is probably true to Say that exploitation beyond the environmentally determined limit for sustained production has occurred. This is because during years of high wool prices farms were either subdivided beyond the economic limit or excessively high prices were paid for additional land. This process of over-utilization has resulted in vegetative deterioration and a decline in production has followed.

In the arid and semi-arid areas of the country, there certainly is scope for increasing production levels of wool and beef. but primarily by means of reclamation of the vegetation rather than by intensification of the farming system. It is also conceivable that farming in the wool-producing Karoo areas will make a considerable contribution to the required increases in human food production by a conversion from wool production to mutton production. The implications of this to the important wool industry in South Africa are tremendous and will not be discussed here. Sufficie it to say that the increased demand for food will most -likely be met by increased intensification of the high rainfall areas long before wool gives way to mutton.

The humid grassland areas of South Africa provide the greatest opportunity for meeting increased food demands by increased production. It is only in these areas that environmental conditions will permit intensification beyond category (iv) in the above list of degrees of pasture intensification.

There are perhaps three phases to the intensification and raised food production levels of the humid grassland areas of South Africa:

(1) The expansion of agronomic activities aimed at producing human food from plant sources.

(2) The conversion of the low-producing natural grasslands to high-producing pastures.

(3) Intensive grazing management of pastures for maximum production.

(1) Increased Crop Production

It has been said that the production of human food in the form of, animal products requires six to seven times as much arable land as the production of comparable calorific value of food from plant sources. The implication of this is simply that, when the demand for food in any one economic system becomes greater than the supply, then all available arable land suitable for the cultivation of annual food crops (e.g., cereals, tubers, legumes) must be used for this purpose. The production of animal products from pasturage will not be able to compete with cash cropping and so pastures and animals will be driven into the hills and other sites less suitable for annual cultivation.

In the humid grassland areas of South Africa, cash cropping will first replace the sown pastures on arable areas and then will extend into all favourable sites which today are still covered by natural grassland. The scope for increased production of human food from plant sources by these means in the high rainfall grassland areas of South Africa is considerable. However, this process of expansion of cash cropping will not be discussed further as our interest in it at present derives only from its effect on pastures.

(2) Veld Replacement by Pastures

Once cash cropping has expanded to its limit in the humid grasslands of South Africa, vast expanses of natural grassland will still remain, largely through, unsuitability for annual cultivation because of steepness, stoniness or shallowness of the soil. However, despite these physiographic limitations, the fact remains that the rainfall is capable of production of pasturage of far greater quantity and far higher quality than can be achieved by the natural grasslands. The conversion of grassveld to high-producing pastures in. all the high rainfall grassland areas of South Africa would represent a tremendous increase in production in animal products from these areas.

The large-scale intensification of these humid grassland areas presents a real and stimulating challenge to the pasture scientist. The problems are complex and varied, and although much can be learned from other countries, notably New Zealand; there are many aspects of the problem which are peculiar to South Africa. Even though this process of intensification is not imminent, already there are a number of research programmes aimed at preparing the way for these developments.

Intensification of these areas will certainly take place gradually rather than by a large-scale, sudden replacement of veld. Probably the first step would be the elimination of the primary limiting factor to production, soil fertility. It has already been shown that veld fertilization can more than double the forage yield from these natural grasslands. Two factors have prevented the large-scale adoption of veld fertilization practices-first, the lack of economic pressures for intensification and, secondly, wariness of the variable botanical changes induced by fertilization. However, the breakdown of botanical composition of the veld will in time be seen as an event leading to ‘the second step in intensification-the surface sowing of seed of grasses with a higher genetic potential for production and an ability to survive and respond to conditions of higher soil fertility, particularly high nitrogen levels. The high cost of nitrogenous fertilizer suggests an alternative approach to the initial stages of intensification-that of reinforcing the veld with legumes.

A large field of work in this connection awaits attention, although initial steps in -these researches have been made. The screening. and testing of suitable temperate and sub-tropical legumes, together with the selection of suitable nitrogen fixing bacteria, for introduction into the veld, has commenced. Also, the techniques for effecting these introductions is beginning to receive attention. By whatever means the process. of ‘intensification is begun, the final objective must be the complete replacement of the natural grasslands with fertilized, introduced pastures so that the present limitations. to- production. soil fertility and the genetic potential for yield, are raised to the level of the existing moisture supply. The methods for achieving this large scale replacement of the dense and highly competitive native pasture with high-producing sown pasture in all the site and topographic variations is; to say the least, challenging.

The whole problem of veld replacement is made that much more complex by problems of site suitability. Remembering that all the best sites will have to be used for cash cropping, the remaining land can probably be divided. into three site classes: (a) Slopes too steep for cultivation but not too steep for occasional seedbed preparation for pasture establishment, (b) Slopes too steep for any seedbed preparation but not. too steep for tractor-drawn implements, and (c) Areas too steep or rocky for any tractor-drawn implements to be used. The methods for achieving intensification in each of these site classes will no doubt be different and each requires separate research attention.

(3) GRAZING MANAGEMENT

While amelioration and fertilization of the soil and the introduction of high-producing species set the stage for production up to the climatic potential in the humid grassland areas, the realization of this level of production of animal products depends largely on methods of grazing management. This is true not only of these improved pastures in the high rainfall areas but also of all existing pasturage from the dwarf shrub veld of the arid Karoo region through the semi-arid natural grasslands and Savannah to the high-producing sown pastures. Grazing man'agement has in recent years become a very controversial issue in South Africa and much confusion has arisen as to what. are the best methbds for sustained maximum production.. The reasons for the confusion are manifold but not the least are the uncritical acceptance of early unproven dogmas, the tendency in thinking to generalize from the particular in a country of great extremes of conditions, and the inability to recognize that different conditions may require different objectives in management and therefore differing methods.

The ruinous effects of continuous overgrazing in earlier times in South Africa presented only two alternatives other than complete destruction of the vegetation-these were either to lighten the stocking rate while still grazing continuously, or to apply'rotational methods of grazing. The first alternative led to continued selective grazing even though it must be recognized that it is possible that stocking rates were not decreased sufficiently. However, this was not an attractive proposition when the other alternative, rotational grazing (relatively few paddocks per group of animals) at higher stocking rates, was giving promising results. Thus, low intensity rotational grazing in order to afford rests and minimize selective grazing has been recognized as optimum management over the last thirty years for all types of pasturage, with certain variations in detail depending on the nature of the pasture. Only recently, in the face of continued deterioration of the vegetative cover, has this premise been thrown into doubt. Two new approaches have emerged which the writer has called High Utilization Grazing and High Production Grazing (Booysen, 1969). There has been a tendency to contrast these as two mutually exclusive viewpoints rather than to recognize that they have different objectives and so perhaps are applicable in different situations or, in a particular situation, they may complement one another.

The High Utilization Grazing approach (Acocks, 1966; Booysen, 1969) emerged out of the arid grazing areas of the country and was developed in recognition of the fact that low intensity rotational grazing had not significantly prevented selective grazing. The basic idea is therefore to have far more paddocks per grazing group (16 is said to be optimum) so that grazing can be applied at high stocking densities for short periods of stay (not longer than two weeks) alternating with long periods of absence. One of the main objectives of the system is to eliminate selective grazing, that is, to get even utilization of all components of the vegetation during the short periods of high intensity grazing. As a means of achieving a high degree of utilization of available and acceptable roughage, the system obviously has merit. As a means of affording long rest periods for recovery of the vegetation in areas of erratic rainfall, the system also has great merit. But, as a. means of improving the composition of the vegetal cover by forcing the utilization of the less desirable species, there must be reservations. This objective will be achieved only if the less desirable species are more susceptible to grazing than the desirable species, otherwise the trend of increase in undesirable species at the expense of the desirable ones will surely continue.

The High Production Grazing approach (Booysen, 1966, 1969) arose out of the recognition that, in many instances at least, the effects of selective grazing cannot be prevented by forcing the utilization of the undesirable species because the more acceptable and desirable species in the sward are always grazed sooner and more severely than the undesirable ones. The primary objective of High Production Grazing is to maintain the desirable plants in a vigorous and fast growing condition so that seasonal production of dry matter from these plants is maximized. This is achieved by leaving sufficient leaf and stubble on the desirable plants after grazing so that the yield is always on the linear portion of the sigmoid growth curve, that is, the growth rate is maximal. Stock must be removed from grazing before the desirable plants are utilized beyond this stage, even though the undesirable plants may never be grazed at all. The hypothesis regarding the selective grazing problem is that optimum utilization of the desirable plant affords it a high competitive ability against an unutilized and moribund undesirable plant.

Recently the writer (Booysen, 1969) described and evaluated these two approaches and it seems clear that each has its place in the scheme of things. In certain situations High Utilization Grazing may best meet requirements, and in others High Production Grazing may be most suitable, and in yet others it may be best to apply High Production Grazing when the plants are growing and High Utilization Grazing when they are dormant. It is, however, important that research determines the best methods of management for each situation if maximum sustained production is to be achieved, not only from the future high-producing improved pastures covering the high rainfall landscapes but also from all the veld and pastures as they exist today. Such a research programme must involve both field trials and physiologically based work in controlled environments.

Field trials have been conducted over the years but a new approach, which is emerging, is required if meaningful and conclusive results are to be obtained regarding the many variable facets of grazing management systems. Rather than a comparison of closed grazing systems, what is required is a field evaluation of each of the facets of management in as near isolation as possible. The influence of number of paddocks, stocking density, stocking intensity, period of stay, period of absence (Booysen, 1967) and many others, on species composition and production must be evaluated separately. The results of this work will provide the means whereby the most desirable degree of utilization dictated by indoor physiological work can best be achieved.

The value of physiological work in controlled environments for solving field problems has not been sufficiently appreciated. The writer has embarked on two programmes of work of this nature which have a direct bearing on the two major influences of grazing management-first, species composition and, secondly, yield.

How to manage a particular pasture in order to obtain a particular shift in species composition can be readily determined if the relative susceptibilities of the desirable and undesirable components to different degrees of utilization are known or, put another way, if it is known how different degrees of utilization influence the relative competitive abilities of the two components. This can be determined in short-term experiments in environment controlled conditions for any pair of species by evaluating competitive effects in relation to differential defoliation (Jones, 1967).

The yield of repetitively harvested perennial pasture crops is determined by the rate of growth of the utilizable components of the sward in the successive inter-harvest periods. In turn, the growth rate of the plants is determined by many factors including five factors inherent in the plant which are directly influenced by harvesting practices. These factors are:

(1) The size of the root absorbing system.

(2) The number of meristematic apices which are the sites for growth of new foliage.

(3) The quantity of reserve carbohydrates available for respiratory substrate and the elaboration of new tissue.

(4) The continuously varying size of the photosynthetic system (LAR).

(5) The efficiency of the photosynthetic process (NAR).

When research has revealed more information on these five physiological factors and their influences and interactions in determining growth, it should be possible to construct a mathematical model for regrowth in terms of these five factors. Only then will we have a sound basis for designing management regimes for maximum yields.

REFERENCES

Acocks, J. P. H., 1966: Non-selective grazing as a means of veld reclamation. *Proc. Grassld Soc.* S. Afr., I: 33-9.

Booysen, P. de V., 1966: A physiological approach to research in pasture utilization. Ibid., *1:* 77-85.

——— 1967: Grazing -and grazing management terminology in Southern Africa. Ibid., 2: 45-57.

——— 1969: An analysis of the fundamentals of grazing management systems. *Ibid., 4:* 84-91.

Jones, R. I., 1967: Outline to a new approach to the study of plant competition. Ibid., 2: 127-36.

Scott, J. D., 1967a: Advances in pasture work in South Africa. Part I, Veld. Herb. Abstr. 37: l-9.

———— 1967b: Advances in pasture work in South Africa. Part 11, Cultivated pastures, Ibid., 37: 159-67.
Tidmarsh, C. E., 1966: Pasture research in South Africa. *Proc. Grassld Soc. S. Afr.*, 1: 21-6.

DISCUSSION

Wolff suggested that four-fifths of the humid area described was native-occupied land and asked if the intensification practices defined could be applied over the whole area. Booysen agreed that much of the area was occupied by Bantu races but not to the extent quoted by the questioner. There was still a very high potential available in the European-occu.pied areas. He thought that the areas occupied by the Bantu could eventually be improved through the knowledge gained from the research outlined.

Scott asked what were the important native and introduced species in the pastures. Booysen listed. Themeda and Andropogons as the more important natives. Among introduced species were Paspalum spp., Kikuyu grass and *Chloris* gayana for summer grasses and ryegrasses, fescues and white clover for temperate pastures. Replacement on the steeper slopes might not be by any of the species mentioned.

Heath (U.S.A.) asked how many sheep and cattle were in South Africa, and how these figures related with those of 20 years ago. Booysen said there were 40 million sheep and 12 million cattle. The numbers of both had been fairly static for some years. To a question on the use of native herbivores, he said that the primary beef breed had been developed from an indigenous type. In the past the pastures were under a high intensity of stocking by antelopes, etc., and this had resulted in a certain rotational type of use. The replacement of these by stock of one or two types in an enclosure had caused a great change. A bigger variety of stock could cause a reversion in pasture. Some game farming was practised but it created management problems.

Asked to describe fertilization practices, Booysen stated that on leached soils, where they depended on the legume constituent, one to two tons of lime were applied at establishment, together with heavy dressings of superphosphate (up to ½ ton/acre), then it was left for some time. On older areas there was a good response to potassium. Nitrogen up to 300 lb N/acre was applied on the more highly productive pastures. There was no indication of other nutrient deficiencies except, perhaps, sulphur and molybdenum. He had no information on the importance of sulphur in establishing clover in a pasture.

They had a programme for the introduction and testing of legumes, but it was still very much at the exploratory level. It was, in fact, rather embarrassing to see some of their own species being improved and used in Queensland. White clover introduced by hand placement was proving most promising, but the problem was to reduce the competitive ability of the native constituents. Lucerne had been oversown into native pastures in trial areas, but little had been done on a practical scale.