

SOME ASPECTS OF GROWING SEASON DEFINITIONS AND
THEIR APPLICATION IN AUSTRALIA

by D.Gaffney

Divisional Office, Perth

(Manuscript received March 1958)

Abstract: This paper defines the term, "growing season", as used by various workers in the Australian region. The theoretical considerations underlying these definitions are reviewed; the particular plant species for which the definitions were evolved are indicated; any authoritative evidence for applicability to other localities or plants is noted; and finally, the possibility of a more consistent use of the term is considered.

1. INTRODUCTION

Growing season is a term applicable with precision only to specific plants in defined localities. In order to clarify and integrate ideas on the subject, it is necessary that the various concepts which have been evolved should be reviewed critically.

It is proposed to review as far as practicable in chronological order, the work that has been accomplished in Australia in this field. The period covered in this survey, begins with a paper by Trumble (1937) and includes studies by several workers up to and including a paper by Vollprecht and Walker (1957).

The intention is not to discuss the details of each investigation or report, but rather to co-ordinate briefly the main results together with the relevant theoretical implications. Studies on the growing season of plants must of necessity be somewhat complex, because they impinge upon other fields such as soil science, plant physiology and botany.

2. REVIEW OF LITERATURE AND THEORETICAL ANALYSIS

Previous to Prescott's 1949 paper, publications by Trumble (1937) and Prescott (1938) had utilised climatic indices to determine rainfall requirements for agriculture. Much of the work carried out in Australia on the growing season is based on earlier studies at the Waite

Institute using the Transeau ratio, P/E and the Meyer ratio, $P/S.D.$ where P = rainfall, E = evaporation, and $S.D.$ = saturation vapour pressure deficit (expressed in the same linear units as P). Trumble used a Transeau ratio of $1/3$ for the break of the season; and Prescott in dealing with tropical Australia, used a value of the Meyer ratio of 5 for the break of the season, and a value of 35 for highest evapotranspirations likely.

Prescott (1949) and co-workers at the Waite Institute derived a formula which superseded the previous indices in accuracy, theoretical interest, and for the purpose of deriving the growing season. The relationship is as follows:

$$\frac{P}{E_w \cdot 0.75} = C$$

P = "Effective Rainfall" - This is defined as the minimum rainfall per unit time needed to maintain growth just above wilting point.

E_w = mean evaporation above a free water surface in unit time.

C = a constant.

The unit of time most commonly used is the month.

From this formula, it was possible to calculate the value of the effective rainfall requirement of wheat for each month of the growing season. The formula enabled a quick and reasonably accurate estimate of the rainfall requirements to be made in the field. An important point in the application of this formula is the need for careful consideration of the definition of effective rainfall. For what some users would refer to as "adequate" growth, a value above the figure for effective rainfall would seem desirable. The definition of effective rainfall appropriate to this formula refers to a limiting value approaching drought conditions.

Prescott applied the formula to plot curves to determine the time of commencement and length of the growing season for wheat. For the locality being considered, those months in which the average monthly rainfall exceeded the effective rainfall calculated from the formula were included in the growing season. Reference may be made to the literature for details of the method. It suffices here to note that the procedure has been widely applied in field studies in Australia.

Prescott, Collins and Shirpurker (1952) selected values of C equal to 1.6 for vegetation of high transpiration and 2.0 for rice fields in the formula $P/E_w \cdot 0.75 = C$. In the same study, maps were drawn showing

the comparison between the length of the growing periods in Australia and Argentina based on the relationship:

$$P/S.D.^{0.75} = C$$

P = mean rainfall per unit time

S.D. = saturation deficit in same units as P

C = constant.

Saturation deficit was used in preference to evaporation (E_w), because more data were available for this parameter. The lines of division between the zones on the maps corresponded to the number of months during which the ratio, $P/S.D.^{0.75}$ exceeded a value of 4. The maps indicated general trends in the growing periods for these two countries. In Australia, the growing period based on this criterion ranged from zero for a large part of the interior of the continent, to 9 months in a fairly wide belt along the east coast.

Hounam (1947-1950) utilised the Prescott formula to determine the effective rainfall for wheat for various localities, notably the wheat belts of Western Australia and New South Wales. In a later paper (1955) this writer applied the relationship to a study of the end of the growing season for sub-terranean clover, taking account of soil moisture storage.

Slatyer and Christian (1948) derived pastoral growing season criteria for the Barkly Tableland Region of Northern Australia based on adequate rainfall figures alone. A map showing regional trends in the time of commencement and length of the growing season for native pastures in this area was constructed from observers' records of pasture response to rainfall. Due to the lack of recorded data on evaporation, no consideration was given in this study to either evaporation or evapotranspiration.

White (1955) showed that natural pastures in western New South Wales can survive and support stock on much less rainfall than that calculated by using a value of the constant $C = 0.54$ in the Prescott relationship. In western New South Wales, White's estimated values for C ranged from about 0.4 at the eastern edge of the wheatbelt to 0.2 in the extreme northwest of the State. White's study was mainly concerned with the determination of drought frequency in a fairly uniform rainfall region in which the growing season is not clearly defined. However the study is relevant here to indicate the need for modification of the constant C to a value appropriate to the existing plant species if the Prescott relationship is to be used to indicate drought limits.

Vollprecht and Walker (1957) determined the average dates of opening and close of the growing season by utilising Prescott's formula. They interpreted their data to indicate that results obtained from

curves using the Prescott relationship for the determination of the length of the growing season agree very closely with those obtained from curves based on mean daily values, and also with results derived by statistical analysis.

3. EVALUATION OF GROWING SEASON CONCEPTS

Having surveyed historically the several studies on the growing season in the Australian region, an attempt will be made to appraise the various views or ideas with the aim of integrating them for the purposes of clarification. Such a process should provide a clearer insight into the factors controlling the growing season; and should yield a theoretical framework for further analyses in this field.

Prescott's relationship generally gives valid results as far as minimum monthly rainfall requirements are concerned, if it is adapted carefully to the environment by appropriate variation of the constant C . The value of $C = 0.54$ gives sensible figures for the minimum rainfall needs of wheat in most of the wheatbelt areas of Australia, but for native pastures towards the drier areas of the continent, and for crops and pastures in Northern Australia, appreciable modification of the value of C is necessary.

In particular, for the wheat belt areas in Western Australia, South Australia and Victoria, where there is a clearly defined winter growing season for wheat, the use of the constant $C = 0.54$ in the formula gives a simple method of estimating minimum monthly rainfall needs. Moreover the average monthly rainfall curve cuts the effective rainfall curve at a sharp angle, to define clearly the start and duration of the wheat growing season. Thus the method can define the regional trends in the time of commencement and length of the wheat growing season in these areas. Such information is of fundamental value for such purposes as indicating the marginal areas of the wheat belt, or in the selection or development of land for wheat growing.

In the wheatbelt of New South Wales, where there is a uniform rainfall, the method is of limited value, since summer rains approximate to the effective amount. Moreover, the extension of the procedure to the natural pastures of the heavier rainfall areas such as the forest regions of the southwest of Western Australia, requires adaptation of the formula, if only because of the vastly different characteristics of the plants.

Towards the drier areas of the continent, where the pastoral industry predominates, the definition of pastoral drought becomes the prime consideration. Growing season criteria in terms of effective rainfall per month are of little significance since the rainfall is highly variable. The natural pastures and herbage in these areas are conditioned

to short period droughts, and generally have lower minimum rainfall requirements than crop plants; they are largely perennial and can therefore respond to unseasonable rains; and they are more responsive to dews.

Sufficient information is not available to assess authoritatively the usefulness of effective rainfall calculations for crops in Northern Australia. However the Waite value of $C = 2.0$ for the constant in the formula in the case of rice fields, seems to yield results which conform reasonably well with the minimum requirements for this crop.

The writer in a study of the effective rainfall and pastoral growing season criteria in the Kimberley region of Northern Australia, found that the Prescott relationship gave valid estimates of minimum monthly rainfall needs, if a suitable value of the ratio, $P/E_w^{0.75}$ was selected. It was evident that $C = 0.4$ gave useful results for native pastures on the heavy soils of the plains of the Ord and Fitzroy regions. On the southern part of the Kimberley Plateau, $C = 0.6$ yielded good estimates of minimum monthly rainfall needs; while on the northern part of the Plateau, $C = 0.8$ was satisfactory.

Since the actual monthly rainfall received is highly variable in Northern Australia, it is considered that a more realistic approach for native pastures would be from the viewpoint of minimum seasonal rainfall needs (P_s) in relation to seasonal evaporation from a free water surface (E_s). This approach was adopted by the writer in the analysis for the Kimberleys.

A criticism of these studies is that, excluding the case of Hounam (1955), no compensation is made for soil moisture storage. Empirical data obtained by Butler and Prescott (1955) with wheat plots revealed a relationship between evapotranspiration and the amount of available water. The latter was expressed in terms of soil storage plus rainfall for any given month. They interpret their findings as an indication of a more economical use of available water at low values than at high values. This is borne out in practice on the West Australian wheatbelt, where some of the best crops can be grown on about 6 ins of seasonal rain if the rainfall is appropriately distributed.

The work of Slatyer (1955 and 1956), shows that evapotranspiration is a function of the moisture content of the soil as well as evaporation from a free water surface. West and Perkman (1953) obtained similar results from investigations into the drying out of soil moisture in a citrus grove. Their moisture extraction curves do not support the view of Veihmeyer and Hendrickson (1955), who interpret empirical data to indicate that transpiration is independent of soil moisture content over the whole range of moisture content from field capacity to a point quite close to the permanent wilting percentage. It is evident then, that there is a need for more research into the measurement of soil storage and its effect on growing season definitions.

4. CONCLUSIONS

Growing season information is of basic importance in fields such as agriculture, pastoral development and hydrology. Its more common uses can be seen in the regional planning for the improvement of natural pastures, the introduction of fodder plants or grasses to check soil erosion, and the selection of the most promising areas for development.

The investigations reviewed bring out the fact that it is essential to evolve effective rainfall (or drought) and growing season definitions appropriate to area and plant species; and that climatic indices or growing season definitions derived for other areas or plants require cautious treatment. In general terms the simple relationship of Prescott can be applied to define the wheat growing season in most of southern Australia; and the relationship can be adapted for natural pastures and rice crops in northern Australia.

The definitions of the growing periods for other Australian crops will need to be evolved by investigation and research. It is probable that simple climatic indices would be derived to calculate minimum monthly rainfall requirements for these crops. The next step would be to ascertain the length of the growing season by the use of curves.

Towards the arid areas of the continent such as the northwest of Western Australia, the term, growing season has little significance, due mainly to the high rainfall variability. The basic problem in these areas, is the definition of pastoral drought so that drought frequency can be determined.

The derivation of a single numerical relationship or technique capable of general application for the determination of the growing season of all plants, is most unlikely. More fruitful results will no doubt be achieved by developing a technique to satisfy the requirements of each case, making full use of the experience gained from other studies.

Applications to pastoral (particularly semi-arid) areas must go beyond the bare preservation of plant life to include assessments of the amount of growth and stock demands.

References:

- | | | |
|------------------------------------|------|--------------------------------------|
| Bath, A.T. and
Fox, W.E. | 1953 | Mimeographed Papers.
Bur. of Met. |
| Butler, P.F. and
Prescott, J.A. | 1955 | Aust. J. Agric.
Res. No. 6, p.52 |

- | | | |
|---|---------|---|
| Everist, S.L. | 1955 | Aust. Met. Mag. No.11, Dec. p.55 |
| Everist, S.L. and
Moule, G.R. | 1952 | Q'ld. J. of Agric. Sc. Vol.9, No.3 |
| Gentilli, J. | 1952 | Mimeographed Papers. Geog. Lab.
Univ. of Western Australia |
| Hounam, C.E. | 1947-50 | Pamphlets Nos. 1-4. Bur. of Met. |
| | 1955 | Met. Study No.4. Bur. of Met. |
| Oppenheimer, H.R. | 1951 | J. of Ecol. Vol. 39, p.356 |
| Prescott, J.A. | 1938 | J. Aust. Inst. Agric. Sc. No.4, p.33 |
| | 1949 | Proc. Specialist Conference in Agric.
Australia |
| Prescott, J.A.,
Collins, J.A. and
Shipurkar, G.R. | 1952 | Geog. Review. Vol. XLII. No.1, p.118 |
| Slatyer, R.O. | 1955 | Aust. J. Agric. Res. No. 6, p.365 |
| | 1956 | Netherlands J. Agric. Sc.4, No.1 |
| | 1956 | Aust. J. Biol. Sc. Vol.9, No.4, p.552 |
| Slatyer, R.L. and
Christian, C.S. | 1948 | Land Res. Series No.3 C.S.I.R.O. |
| Trumble, H.C. | 1937 | Trans. Roy. Soc. South Aust. 61, p.41 |
| | 1945 | J. Aust. Inst. Agric. Sc. Vol.II, No.3 |
| Veihmeyer, F.J. and
Hendrickson, A.H. | 1955 | Trans. Am. Geophys. Union, Vol.36, No.3 |
| Vollprecht, R. and
Walker, D.R. | 1957 | Aust. Met. Mag. No.17, June, p.37. |
| West, E.S. and
Perkman, O. | 1953 | Aust. J. Agric. Res. 4, No.3 |
| White, R.C.L. | 1955 | Met. Study No.5, Bur. of Met. |