Phase farming grains with lucerne in South-east Australia

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ABSTRACT

Effects of autumn soil water deficit on winter water balance in south eastern Australia revealed that run-off and deep drainage (RODD) were effectively minimised by estimates of the local sum of evapotranspiration + soil storage (SET) that decreased RODD to a mean rate of 10 mm p.a. Estimates of autumn soil water deficit corresponding to the target values of SET (B10) were compared against the experimental measures of autumn soil water deficit afforded by annuals and lucerne to describe the spatial hydrologic limits of annuals and lucerne, respectively. The comparison of component vegetation buckets (autumn soil water deficit) with estimates of B10 positioned species in the winter rainfall spectrum, and so determined the spatial application of vegetation options within the Grains Region of south eastern Australia. The intermediate zone where crops leak and lucerne affords hydrologic control is appropriate to the phase farming of crops with lucerne.

KEYWORDS

Lucerne, annuals, recharge control, autumn soil water deficit.

INTRODUCTION

The principles of the causal relationship linking ground water discharge and ground water recharge are now widely accepted in SE Australia. Two basic approaches to the siting of recharge control measures have emerged as a result of a partial understanding of rates of recharge, on one hand, and hydrogeological pathways, on the other. Intervention modeller attempt to relate discharge to recharge and hydrogeology, with the ultimate aim of mitigating discharge by customised management of targeted sites in the landscape.

The degree of sophistication of the interventionist approach varies from the focus on land management units in salinity management plans to the prospective application of complex, demanding models in various stages of theoretical development. The agronomic approach adopted here is based on the need to identify and manage zones of excess water in the landscape. The water use capability of species, expressed in terms of autumn soil water deficit, is taken as the starting point in the analysis. The ultimate implementation of intervention models depends on the development of practical, robust models that provide the spatial relationships of discharge and recharge. All approaches ultimately rely on efficient practical methods of recharge control, and are subject to the on-going emergence of new technologies that allow, for example, the mapping of sub-surface salt in landscape.

This work was directed towards an appraisal of the need for hydrologic intervention with lucerne in grain enterprises in mainland SE Australia, and to the strategies that apply in the designated areas. This paper focuses on the designation of areas where lucerne intervention is most appropriate in SE Australia. The approach relied on an appraisal of the effects of autumn soil water deficit on winter water balance.

MATERIALS & METHODS

According to the water balance equation, winter (May – August) rainfall (RF) is dissipated as evapotranspiration (ET), in soil storage (S), or runoff and deep drainage (RODD). That is

$$RF = (S + ET) + RODD \tag{1}$$

Because of its dependence on annual trends in solar radiation, ET is relatively predictable between years whereas RF shows major annual variability. Soil storage, S, therefore emerges as the major management variable affecting the partitioning of RF to RODD at a designated site. The relationship between RODD and S + ET (denoted SET) was first investigated for Walpeup and Wagga Wagga. Outcomes of that analysis were extended to mainland SE Australia to establish site-specific values of SET conducive to an hydrologically 'acceptable' target value of RODD for the winter-dominant rainfall zone of SE Australia.

RESULTS AND DISCUSSION

Figure 1 shows the cumulative frequency distributions appropriate to May - August rainfall at Walpeup in NW Victoria and Wagga Wagga, southern NSW. The available record included 84 years of data, spanning the period, 1912 – 1997, for station 76065, at Walpeup, and 113 years relating to the period 1871 – 1984, at station 72151(Wagga Wagga). The data clearly distinguish the arid rainfall regime at Walpeup (mean May - August rainfall = 133 mm, range 32 - 271 mm; Fig. 1) from the humid regime at Wagga Wagga (mean May - August rainfall = 211 mm; range 45 – 409 mm).

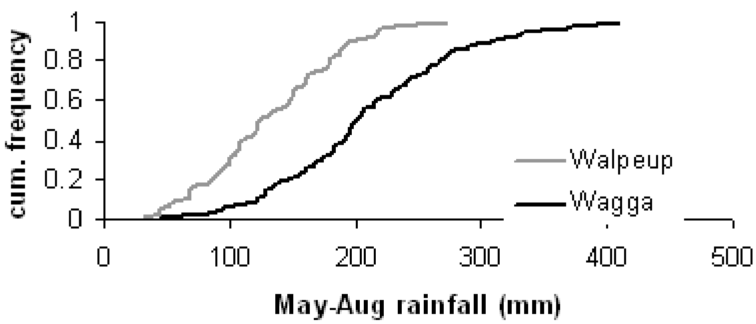

Figure 1. Cumulative frequency distributions appropriate to May – August rainfall at Walpeup and Wagga Wagga

Change in RODD (mm p.a.) with change in SET (determined by applying Eq. 1 to the range of May-August rainfall appropriate to Walpeup and Wagga Wagga.) shows that rainfall available for RODD is reduced to a mean of 10 mm per annum if SET accounts for approximately 160 mm and 270 mm of May - August rainfall at Walpeup and Wagga Wagga, respectively (Figure 2).

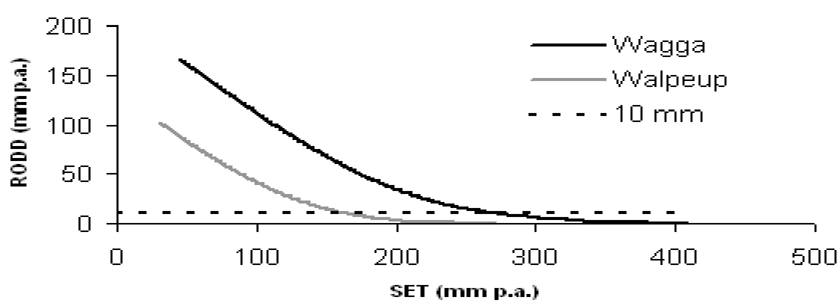

Figure 2. Change in mean annual RODD with increase in amount of May-August rainfall partitioned as storage + evapotranspiration (SET) at Walpeup and Wagga Wagga. The dashed line indicates the value, RODD = 10 mm p.a..

Fig. 2 shows that rainfall contributing to RODD decreases rapidly for low values of SET, and more slowly thereafter as progressive increments in SET fail to account for years of high May - August rainfall.

Additional reductions in RODD are achieved at the expense of large increases in SET once RODD has been reduced to 10 mm p.a. The estimate of SET that results in the value, RODD = 10, therefore afforded an appropriate pragmatic target of SET. The attendant autumn soil water deficit was estimated by subtracting estimates of actual ET for the period, May – August, from threshold values of SET. These estimates of site-specific autumn soil water deficit are necessary for hydrological control in the landscape.

ET accounts for approximately 60 and 110?mm of May - August rainfall at Walpeup and Wagga Wagga, respectively (Q. J. Wang, pers. comm.). Estimates of SET appropriate to the prescriptive value, RODD = 10 mm (Fig. 2), therefore depend on an autumn soil water deficit (Bucket, B10) of ca. 100 mm (SET = 160 mm) at Walpeup, and a B10 value of ca. 160?mm at Wagga Wagga (SET = 270 mm).

The areal estimates of B10, shown in Fig. 3, were derived for all sites in SE Australia that provided a minimum of 15 years of record of May-August rainfall. They are compared with values of the mean autumn soil water deficit imparted by annual crops (wheat, barley, canola, safflower, lupin and pea) and pastures, and deep-rooted agronomic perennials (lucerne and phalaris) grown on a red-brown earth in northern Victoria by Whitfield et al (1), who ascribed a soil water bucket (B10) of 135 mm to annual crops and pastures, and a B10 value of 185 mm to lucerne.

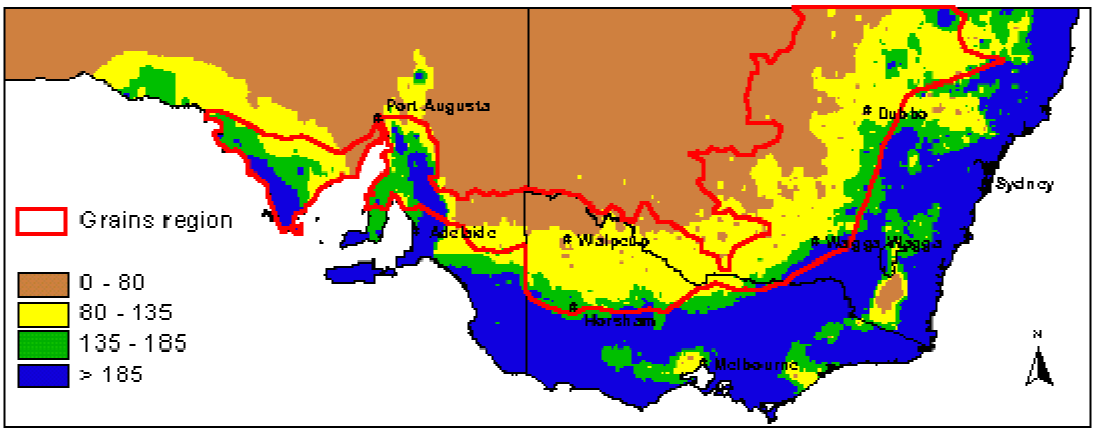

Figure 3. Spatial distribution of autumn soil water deficit (mm) required to reduce May - August RODD to 10 mm p. a. (B10) in S. E. Australia. The red line marks the Southern mainland Grains Region.

The region, B10 ≤ 80 mm, accounted for 28% of the southern Grains Region. A further 42% of the Grains Region (22% of the total area shown in Fig. 3) was characterised by 80 ≤ B10 ≤ 135 mm. Annual crops and pastures therefore suffice for hydrologic control over 70% of the Grains Region, subject to the proviso that they dominate land use.

This major arm of the Grains Region in Eastern Australia is flanked on the east and south by a zone (18% of southern Grains Region) where the additional 50 mm of soil water deficit conferred by lucerne restricted RODD to a maximum of approximately 10 mm p.a. (B10 ≤ 185 mm). Alternative high-water-use strategies are required for recharge control in the remaining 12 % of the Grains Region where B10 exceeded the autumn soil water deficit afforded by lucerne.

B10 ranged to a maximum of 1630 mm outside the Grains Region (data not shown). With several clear exceptions, lucerne was found to be only partially effective in recharge control in high rainfall areas outside the grains region.

The limited proportion of the grains industry in the rainfall zones, 135 ≤ B10 ≤ 185?mm, where lucerne affords effective recharge control, and areas where lucerne leaks (B10 ≥ 185 mm), primarily demonstrates the extent to which the grains industry has been shaped by the dual needs for

- arable land on the plains beyond the slopes, and
- a May - August rainfall regime that substantially restores the soil water consumed by previous crops, with minimal waterlogging.

CONCLUSION

The comparison of component vegetation buckets (autumn soil water deficit) with estimates of B10 (based on May-August rainfall) positioned species in the winter rainfall spectrum, and so determined the spatial application of vegetation options within the Grains Region. The intermediate zone, where crops leak and lucerne affords hydrologic control, is appropriate to the phase farming of crops with lucerne.

REFERENCES

Whitfield, D. M., Newton, P. J., and Mantell, A. 1993. Proc. 6th Aust. Agronomy Conf., pp. 262 – 65 (Aust. Soc. Agronomy, Parkville, Vic.).