Pasture cropping in northern NSW – do the numbers for plant available water stack up?

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Abstract: *Model simulation of soil water content and analyses of 100-year rainfall records indicated that for a site near Barraba, pasture cropping for grain or dry matter production would fail in 36% of years. On May 1, the median predicted plant available water in the profile was 8 mm and there was a predicted soil water deficit for plant growth in 42% of years. To achieve a grain yield of 2.1 tonnes/ha (district average) or dry matter (DM) production of a moderately low amount of 3 tonnes/ha would require in-crop rainfall equivalent to the 69th and 25th percentile values (or 367 and 258 mm), respectively.*

Introduction

Pasture cropping is a zero till technique of sowing annual cereal crops into living perennial pastures (Anon. 2010). The concept evolved for the sowing of winter-growing crops into a dormant stand of summer-growing native grass, such as redgrass (*Bothriochloa macra*) in autumn, but has subsequently been applied to a wider range of pasture types. It has been widely promoted by Colin Seis, "Winona", near Gulgong in central NSW, with each enterprise (grazing and cropping) apparently enhancing the other both economically and environmentally. Pastures are grazed in the summer prior to sowing, reducing the loss of grazing associated with the soil preparation and weed control required in traditional cropping methods. Herbicide (1 L/ha of glyphosate or paraquat/diquat mixtures) may need to be applied at the end of April to control winter-growing annual grasses and weeds, and the system relies on the summer-growing perennial grasses being winter-dormant and so providing little competition for moisture in the winter-spring period.

In northern NSW, rainfall is mainly summer dominant, with ~60% of total annual rainfall occurring between November and March, and ~35% falling in December–February. For this reason most winter-grown cereal grain crops are grown on soil moisture stored in a fallow phase which can vary from 5 (short-fallow) to 12 (long-fallow) months, with producers only sowing crops when stored soil moisture reaches a minimum depth of 0.5 m (opportunity cropping) or 1.0 m for longer fallows. Unlike the southern and central winter rainfall zones of NSW, 'in-crop' rainfall (mean rainfall between sowing and harvest) in northern NSW is usually insufficient to produce adequate cereal grain yields in most years. In south-eastern Australia, the average water use efficiency (WUE) of rainfed wheat is 9.9 kg of grain/ha/mm of water (Sadras & Angus 2006) and in northern NSW, several studies have indicated that the average WUE for winter cereal grain production is 10 kg/ha/mm (e.g. Young *et al.* 1998).

In this paper, historical climate data (1906–2005) for the Sustainable Grazing Systems (SGS) experimental site located near Barraba in northern NSW was examined by a two-stage process to test the hypotheses that: (1) predicted profile soil water content (SWC) on 1 May each year of a grazed, native perennial grass pasture would be below the level required to initiate crop growth in a high proportion of years, and (2) in most years 'in-crop' rainfall would be insufficient to grow a cereal grain crop.

Methods

Profile SWC of a grazed, native grass pasture on 1 May each year was estimated by modelling, and monthly rainfall data from May (sowing) to November (harvest) were used to indicate the likelihood that initial stored soil water and subsequent 'in-crop' rainfall would provide sufficient water for cereal crop growth based on WUE values for grain and dry matter production. A fully parameterised version of the SGS Pasture Model (Johnson *et al.* 2003; version 3.4.6) and daily climate data from the SILO Data Drill (Jeffery *et al.* 2001) for the SGS site at "Springmount" (30° 34'S; 150° 38'E; 510 m a.s.l.), 20 km south-east of Barraba on the North-West Slopes of NSW, were used to simulate SWC. This site was described in detail by Lodge *et al.* (2003). In the simulations, the soil profile depth was 2.1 m, the pasture was a C_3 /C_4 native perennial grass-based pasture set stocked with 4 Merino wethers/ha, and the soil parameterisation was for a Red Chromosol (Isbell 1996). To avoid nutrient deficiencies in the simulations, fertiliser nitrogen (N) was applied to ensure that it was non-limiting.

Daily total SWC (mm) in the profile was simulated for the long-term (100-year) period from 1 July 1905 to 30 June 2005 using the procedures outlined by Lodge & Johnson (2008*a*). The minimum total SWC (0–2.1 m) for native perennial grass growth at this site was 410 mm (Lodge & Johnson 2008*a*). Above this value the soil profile was considered to have an available water store (AWS) and below this value it had a soil water deficit (SWD) for pasture growth. Predicted SWC values for the first day of each month (Lodge & Johnson 2008*b*) were extracted from the full dataset, with those for 1 May each year being used in the current study. For each simulation, daily rainfall data were summed to monthly and annual values and summarised using mean and percentile values. A percentile is the value below which a certain percentage of all observations fall, with for example, the10th percentile for annual rainfall indicating the upper value for the lowest 10% of years and the lower value for 90% of years.

For winter cereal dry matter (DM) production, a WUE value of 20 kg/ha/mm (Young *et al.* 1998) was used and the efficiency of converting rainfall to stored soil moisture was assumed to be 55% (Murphy *et al.* 2010). It was also assumed that a minimum of 10 mm of rainfall was required in both May and June for cereal crop germination and establishment.

Results and discussion

For the 100-year period 1906–2005, mean rainfall from May to November (inclusive) was 319 mm. Model simulations indicate that pasture cropping of a native pasture would have produced no grain or DM in 36 of these years. This failure was associated with insufficient rainfall for germination and establishment and/ or less than 110 mm of available water to take crop growth to the canopy closure stage (Scott *et al.* 2009). There was a predicted SWD for plant growth on 1 May in 42 of the 100 years, indicating that, at the Barraba site, a grazed C_3/ C_4 native perennial grass pasture would have no water available for plant growth at this time of the year in 42% of years. Further, in another 40% of years, there was predicted to be <50 mm of water available for plant growth on 1 May. AWS was predicted to be >100 mm on 1 May in only 3 years (1908, 1956 and 1964).

Rainfall was ≤10 mm in May for 36 years and in June for 32 years and so in these years it would be highly unlikely that there would be sufficient rainfall for a sown crop to germinate and establish. Therefore in at least 36 out-of-100 years, pasture cropping would have failed, even if there was sufficient soil moisture on 1 May. Altogether there were 14 years in which there was a predicted SWD on 1 May and rainfall in May was ≤10 mm and six years in which there was a predicted SWD and rainfall in both May and June was ≤10 mm.

The median (50th percentile) predicted AWS in the profile on 1 May was 8 mm (mean value 10 mm). This indicated that in about half of the years 'in-crop' rainfall would need to supply most of the water for grain or DM production.

To achieve the average district wheat yield of 2.1 t/ha (Martin *et al.* 1988) 210 mm of AWS [i.e. 2100 kg/ha @ 10 kg/ha/mm)] would be required, or for a modest 3 t/ha DM production, 150 mm would be required. Therefore in 50% of years an additional 202 mm of soil water would need to be added to the profile or 367 mm of rainfall (i.e. 202/0.55) would be required from May–November to achieve average district grain yields, and 258 mm of rainfall for DM production. To achieve these rainfall amounts over the 100-year period would require rainfall events equivalent to the 69th percentile for grain production and the 25th percentile for DM. For the 64 years that a crop was likely to germinate and establish, the equivalent values are the 53rd percentile for grain and the 8th percentile for herbage, indicating that a yield of 2.1 t/ha would be achieved in only 47% of the 64 years (i.e. 30 years), whereas 3 t DM/ha could be achieved in 92% of the 64 years (59 years).

These analyses indicated that in most years there is a low likelihood of adequate soil water being available to initiate crop growth or to achieve average district cereal grain yields with pasture cropping and the practice would therefore be a "high risk" strategy in northern NSW. It should also be noted that the predicted grain and dry matter production values would only be achieved with adequate N fertiliser inputs. Further, in northern NSW, to ensure the availability of early winter feed, it is recommended that most forage oat crops be sown in mid to late February to avoid the dry autumns.

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