Evaluation of Sorghum in Western Australia

Andrea Hills[1], Michael Robertson[2], Don Gaydon[2], David Hall[1], Trevor Lacey[1], Arjen Ryder[1]

[1] WA Dept of Agriculture Locked Bag 4, Bentley 6983 www.agric.wa.gov.au ahills@agric.wa.gov.au
[2] CSIRO Brisbane Michael.Robertson@csiro.au

Abstract

The WA wheatbelt has winter dominant rainfall but in some regions, up to 37% of average annual rainfall can fall outside the traditional May to October growing season. By using out of season rainfall and subsoil moisture, forage or grain sorghum is being investigated as an option that may prevent or reduce winter waterlogging and groundwater rise. Eight sites were monitored for sorghum growth and water use throughout WA while the crop growth model APSIM was used to evaluate the opportunities for sowing sorghum at the Scaddan site given historical rainfall records. This study found that the water use of sorghum echoes rainfall during the growing season, although occasionally water use can be substantially higher. Grain production is risky due to variable summer rainfall distribution while forages are a safer alternative with APSIM predicting commercial levels of production attainable in many years if sowing is complete by end December. Evaluation of sorghum and other warm season crops for WA continues.

Key Words

sorghum, water use, dry matter, yield, APSIM, Western Australia

Introduction

Historical background

Summer crops have been grown in southern WA for many years. In the late 1960s and 1970s, wheat quotas forced farmers to seek alternative cash crops. While much of the research during this period concentrated on alternative winter crops, summer crops such as sorghum, sunflowers and safflower were also investigated. The results from this work reflected seasonal conditions and consequently were highly variable. For instance, Parkin and Fisher (1969) conducted a number of experiments in the Esperance area during 1968/69. They found that sites at Esperance Downs (30 km north of Esperance) failed due to inadequate rainfall during December, however sorghum yields at Condingup (60 km east of Esperance) averaged 1.2 t/ha (range 0.6 – 2.8 t/ha). Following the removal of wheat quotas in the 1970s the imperative for summer crops was diminished.

Current farms systems issues

WA interest in summer crops revived in the mid 1990s as farmer groups such as the WA No-Till Farming Association (WANTFA) encouraged diversification of crop rotations and the use of cover crops to build soil fertility. In addition to this, uncommonly wet summers (eg. Esperance 1998/99 and 1999/00; Moora 1999/00) have focused attention on out of season rainfall. These extreme rainfall events, although in summer, depressed some winter crop yields by increasing the extent and duration of waterlogging. In some regions, rain falling outside the winter crop season of May to October may be up to 37% of average annual rainfall. Anecdotal evidence from farmers who have grown summer crops is that following winter crops do not waterlog as badly (K. DeGrussa, pers. comm.). Hence, there is an expectation that summer crops will reduce ground water recharge (State Salinity Action Plan 2000) and lower the risk of winter waterlogging, although this has not been formally investigated.

Other advantages to the farming system include a new cash crop, control of herbicide resistant weeds over the spring / summer period, increased diversity of crops grown in a rotation, green summer stock feed and increased soil fertility. Soil fertility benefits may derive from green manuring, increased soil nitrogen levels (if legumes are grown), or by using species with greater soil rooting depth and penetration to ‘open’ soil layers impenetrable to winter crop roots. Summer crops grown as annual plants also give farmers a flexible summer water use option within a cropping rotation.

In this paper, the potential of sorghum to grow and yield economically and use out of season rainfall and stored soil water is discussed based on crop trials throughout the agricultural region and simulations using the APSIM crop growth model.

Methods

Sites monitored included replicated plot trials, large ‘farmer scale’ trials and farm paddocks. Measurements recorded were plant density, dry matter production, grain yield and soil water content. Grain varieties grown were Legend? and Western Red? while forages included Bettagraze? and Pacific Brown Mid Rib?. At Neridup and Buntine, sites were different varieties within a trial, Scaddan sites 1-3 were of the same variety but increasing row spacings and Bruce Rock 1, 2 were different paddocks. Soil water use was calculated using; Total Water Use = Rainfall + (initial soil water content – final soil water content).

Table 1: Location, average annual rainfall, soil description, crop and time of sowing of sites monitored.

Location	Annual Rainfall (mm)	Soil Type	Sorghum Grown	Date of Sowing
Kendenup	611	Loamy sand over clay at 0.12-0.3m	grain	20-Oct-98
Scaddan	411	Sandy loam over alkaline clay at 0.15m	grain	11-Oct-01
Mt Madden	370	Loam over alkaline clay at 0.15-0.2m	grain and forage	22-Oct-01
Neridup	490	Sand over clay at 1.4m	grain and forage	19-Oct-01
Wickepin 1	415	Sandy gravel over reticulite at 0.4m	forage	1-Nov-01
Wickepin 2	415	Deep sand	forage	1-Nov-01
Bruce Rock	334	Sand over clay at 1m+	forage	7-Oct-01
Buntine	340	Sandy loam graduating to clay loam at 0.6m	forage	26-Sep-01
Yealering	374	Sand over clay at 0.4m	forage	19-Nov-01

Results

Trials and Paddock Monitoring

Eight sites throughout the WA agricultural region were monitored for sorghum growth and water use.

Grain yield across the sites was variable and very low at the Scaddan site where many heads failed to emerge or set seed. Rainfall distribution and moisture stress at crucial plant development stages are responsible, with very little rain received throughout the WA agricultural regions after mid December 2001. Rainfall distribution during summer is a critical factor for those attempting to grow grain crops and APSIM is being used to assess seasonal risk (see section following) but implications of a failure are expensive and even grazing a failed grain crop carries a poisoning risk.

The dry matter production and grain yield of sorghum is highly variable across WA, with better dry matter yields as rainfall increases. Yields vary according to soil type (Wickepin) or variety adaptation such as at Neridup, where Pacific BMR (site 1) performed better than Bettagraze (site 3). At Scaddan, increases in row spacing from 0.5 m (site 3) to 1m (site 2) and 1m skip rows (site 1) resulted in less dry matter produced.

At most sites, total water use was similar to rainfall received or exceeded it by around 20 – 35 mm. Exceptions were Kendenup, where an additional 89 mm of soil moisture were used, and Neridup, where 40 – 65 mm less than the rainfall total were used. The Neridup result is likely to be from 42 mm of rain falling five days prior to harvest so that crop response time was limited. That even poorly performing paddocks can use water above that of the rainfall received (eg. Bruce Rock 2 and Wickepin 2) may mean that potential benefits to the following winter crop, by preventing or delaying waterlogging, are not restricted to soil types that can produce high levels of dry matter.

Internationally, dry matter WUE for rainfed sorghum can reach 68 kg DM /ha / mm (Owonubi and Kanemasu, 1982; as cited by Kanemasu *et al,* 1984) and within Australia, APSIM uses 90 kg DM /ha /mm (at 1 kPa vapour pressure deficit). Figure 1. shows how the WUE of these sites relates to these benchmarks, our maximum WUE being 27.9 kg DM /mm /ha. Limits to WUE in WA are soil related (physical and chemical impediments to root growth) but vary site by site. Most of the soil profiles monitored had bulk densities inhibitory to root growth (1.7 g/cm^3 or greater) within 70cm of the surface. Poor water holding capacity and subsoil nutrition are also common features of WA soils. Agronomy to improve the WUE of dry matter production must combat these factors where possible.

If WUE can be improved to achieve levels of 30 kg dm/mm rain/ha, then even areas receiving 100 mm of summer rain could expect to grow 3.0 t/ha of dry matter for forage purposes if the soil depth is reasonable (see APSIM simulations for Scaddan site).

Table 2. Sorghum monitoring results.

Location	Rainfall * (mm)	Total Water Use (mm)	Plants/m^2	Final DM (kg/ha)	Grain Yield (kg/ha)	kg DM/mm water used
Kendenup	136 (172)	225	13.4	3600	2000	16.0
Scaddan 1	147 (140)	183	3.8	1160	17	6.3
Scaddan 2	147 (140)	176	3.8	2410	52	13.7
Scaddan 3	147 (140)	165	3.8	3060	69	18.5
Mt Madden 1	129 (137)	159	7.5	2649		16.7

Mt Madden 2	129 (137)	150	10.1	4198	1102	27.9
Neridup 1	200 (160)	161	12.1	2070		12.8
Neridup 2	200 (160)	144	3.1	1267	347	8.8
Neridup 3	200 (160)	135	2.2	1430		10.6
Wickepin 1	68 (94)	90	8.7	1694		18.9
Wickepin 2	68 (94)	83	7.0	504		6.1
Bruce Rock 1	60 (99)	97	6.1	1214		12.5
Bruce Rock 2	60 (99)	89	2.9	200		2.3
Buntine 1	85 (88)	84	4.1	944		11.3
Buntine 2	85 (88)	84	3.7	1100		13.1
Yealering	79 (90)	70	6.9	1691		24.1

*Rainfall for the period from sowing to when monitoring ceased, with long term average for October to March in brackets.

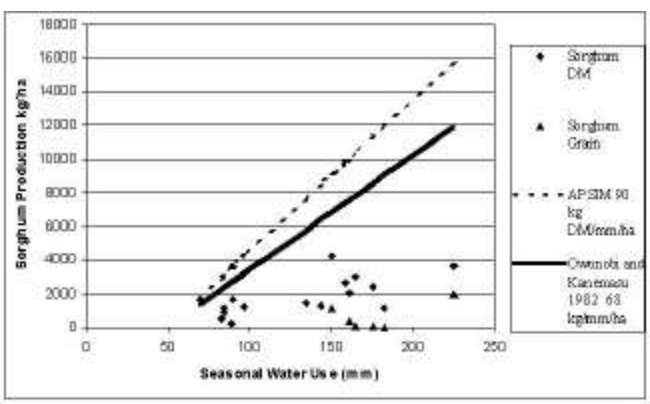

Figure 1. Water Use Efficiency (kg /mm /ha) of dry matter and grain for sorghum in WA, as compared to international and Australian benchmarks.

Application of systems simulation

An evaluation of the risks and benefits of summer cropping is difficult to make on the basis of field experimentation and farmer experience alone due to the large impact of climate (particularly rainfall) variability and the interaction with soil type, management and crop species / cultivars. Consequently, systems simulation using APSIM is being used to analyse the within-season dynamics in field experiments involving summer crops. Findings from field experiments are then extrapolated to a wider range of seasons using the historical climate record, and to other soil types and management regimes.

Long-term simulations using the 1957-2001 historical climate record for Scaddan were used to place the 2001-02 results into an historical perspective and to provide a risk assessment of growing grain sorghum on two soil types, one of which was present at the experimental site (Fig. 2).

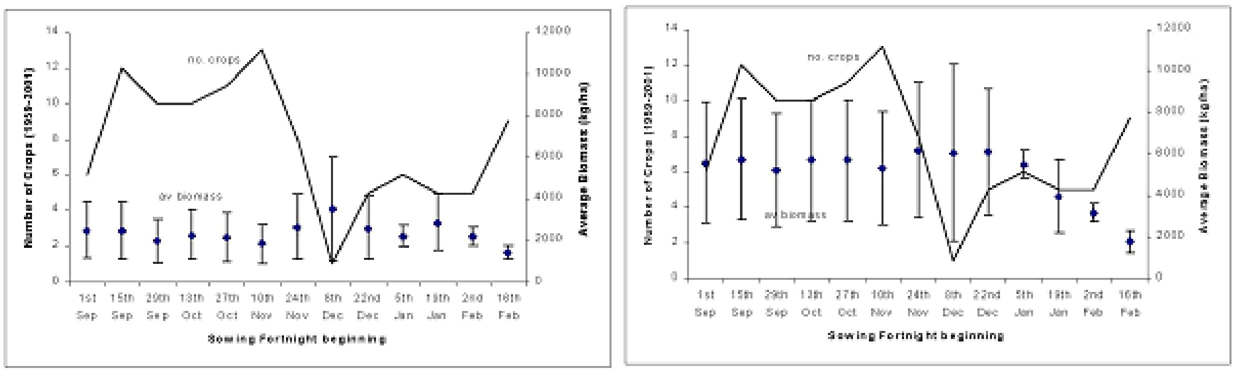

Figure 2: Long-term simulations (1957-2001) of sorghum biomass at Scaddan for a shallow sand (15 cm) over clay (left) and a deep (100 cm) sand (right). Simulated crops were sown during fortnightly windows from 1st September to 15th February if at least 20 mm rain fell during the previous 14 days. Error bars for biomass represent +/- one standard deviation from the mean.

The simulations for the sand over clay suggest that the field results of around 3 t/ha dry matter from a 11 October sowing was similar to the long term average for Scaddan. Variability is considerable around the mean, indicating that the long term risks are quite high. Simulated productivity on the deep sand was higher, although season-to-season variation was greater than on the shallow duplex. Simulations for sowings later in the year indicate that the likelihood of a sowing event drops off considerably after mid November and average sorghum productivity also declines markedly after late December, particularly for the deep sand.

Conclusion

Across a range of areas in WA, sorghum crops can grow useful levels of dry matter, however, grain production is limited by the highly variable rainfall distribution. Given this situation, regular grain crops may be confined to southern-most areas of WA which receive higher summer rainfall. Sorghum agronomy for poor, sandy soils needs to be improved to maximise water use efficiency. Water use of sorghum was similar to it's growing season rainfall and investigations are continuing into the impact of this (beneficial or otherwise) on winter crop growth. The water use and production potential of other summer crop species are being investigated. APSIM will also be tested under a wider range of seasons, soil types and crop species / cultivars. Results from simulations will be used to provide a rational assessment of the risks with summer cropping in different rainfall zones and soil types in WA.

Acknowledgments

We would like to acknowledge the Grains Research and Development Corporation for funding this work. Other contributors for site monitoring were; Anne Jones and Richard O'Donnell (WA Dept. of Agriculture) and Haley Walker (Community Landcare Coordinator). The technical support of Vanessa Johnson is appreciated.

References

(1) Parkin R.J. and Fisher H.M. (1969) Grain sorghum production at Esperance, part II, report on experiments 1968/69. Western Australian Department of Agriculture (Perth) 1969

(2) State Salinity Council, Government of Western Australia (2000) Salinity Actions

(3) Kanemasu E.T., Singh P. and Chaudhuri U.N. (1984) Agrometeorology of Sorghum and Millet in the Semi-Arid Tropics: Proceedings of the International Symposium 1982. ICRISAT