Summer/Autumn Fallow Management Strategies for Improving the Rainfall Use Efficiency of Crops in SE Australia

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Abstract

In the low and medium rainfall zone of south-eastern (SE) Australia summer rainfall is ineffectively used by subsequent crops due to high evaporative losses. Climatic prediction suggests a future of increased frequency of episodic summer rainfall events and decreased in-crop rainfall. Therefore, it is important to development management strategies that better utilise summer/autumn rainfall by subsequent crops by enhancing rainfall capture and increasing soil infiltration into the subsoil, where evaporative losses are minimised. To identify strategies to better capture summer/autumn rainfall, a field experiment was conducted on a heavy clay (Vertosol) in 2020 at Horsham, Victoria with five different fallow management strategies; short fallow (control) , long fallow, heavy mulching (10t/ha), plastic sheet (on ridge) and application of hydrophobic polymer (on ridge) applied for wheat (deep rooting) and lentil (shallow rooting). Crop growth and water use were monitored throughout the season. High wheat and lentil yields were obtained in the study year reflecting high growing season rainfall (GSR = 287 mm; Decile 7). Other field and modelling experimentation are currently in progress to assess the relative effectiveness of the different management treatments under a range of seasonal rainfall conditions and soil types.

Keywords

Water use efficiency, climate change, biodegradable polymer

Introduction

Summer fallowing (4-6 months) following harvest of one crop aims to increase soil water supply prior to winter sowing. However, in the low and medium rainfall zone of SE Australia summer rainfall often makes little contribution to subsequent crops yields due to high evaporative losses with the importance of summer fallow rain towards the winter crop production generally overlooked (Freebairn et al., 2015; Hunt & Kirkegaard, 2011). However, the impact of the millennium drought on reductions in both winter and spring rainfall and predictions of increased summer extreme rainfall events in future climates (Hennessy et al., 1997; Jakob et al., 2011; Ashcroft et al., 2019), have renewed interest in summer fallow rainfall management. To date the most commonly used management approaches for fallow water management centre on the use of soil water by the crop itself viz. altering the period of crop growth by bringing forward the time of sowing to avoid grain filling during terminal drought (Hochman et al., 2016; Hunt et al., 2019) or by increasing early vigour (Rebetzke et al., 2004). However, the ratio of rainfall converted into soil water is poor (O'Leary and Connor, 1997), especially during the summer fallow period between harvest of one crop and sowing of the next. In temperate cropping areas of southern Australia when daily temperatures and evaporation rates can be very high(> 10 cm/day), this 'fallow use efficiency' can be increased by reducing losses of soil water by better control of weeds (Hunt et al., 2013) but relatively little attention has been paid to engineering approaches. The use of reduced tillage/stubble retention systems can significantly increase infiltration (Bissett and O'Leary, 1996) but the effectiveness of current residue loads (2 to 10 t/ha in low to medium rainfall zones) on reducing evaporative losses is unclear. Questions still exist regarding the amount and type of residue required to efficiently harvest the rainfall (Verburg et al., 2012). Similarly, plastic mulching has been utilised in high intensity horticulture systems, but it entails environmental concerns and is unlikely to be economically feasible for rainfed Australian grain production systems. Under such scenarios, biodegradable sprayable polymer, which has shown high potentiality for conserving the soil water in horticulture industry, may be a suitable alternative. We are using a field based and computer simulation approach to assess the potential of using such polymers to concentrate runoff from intense summer rainfall events into narrow bands to potentially increase the infiltration into clay subsoils so that evaporative loss can be minimized, and rainfall use efficiency can be improved. This research is based on the logical premise that during large episodic summer rainfall events, if rainfall can be channelled towards the furrow, water is more likely to infiltrate to soil depths where evaporative losses will be nominal and increased water will be available to subsequent crops.

Methods

A field experiment was established on a heavy clay (Vertosol) soil in 2020 following a chickpea crop at the Plant Breeding Centre (36°44'53.4"S 142°06'56.0"E) in the Victorian Wimmera region. The experiment comprises five different management treatments: Short fallow, Long fallow, plastic sheet (on the ridge), hydrophobic polymer (on the ridge) and heavy mulching (10 t/ha of crop residue). Two crops with differing rooting patterns, wheat (Triticum aestivum cv. Scepter; intermediate-deep rooting) and lentil (Lens culinaris cv. Jumbo2; shallow rooting) were selected for the study. A furrow-ridge system (ca. 15 cm deep and 40 cm row spacing) was established (Figure 1). We used the wider row spacing (most commercial crops in this region are 25 to 30 cm) to ensure the rainfall water can be channelled towards to the furrow. We hypothesized that the fallow management strategies will increase the rainfall use efficiency and productivity of crop species with different rooting pattern. Along with the field experiment, a simulation modelling approach is being conducted using the Agriculture Production Systems sIMulator (APSIM) to simulate the fallow water balance and crop growth using long-term weather data for key locations/soil types in western Victoria. Data collected from the field experiment will be used to initiate and validate the model.

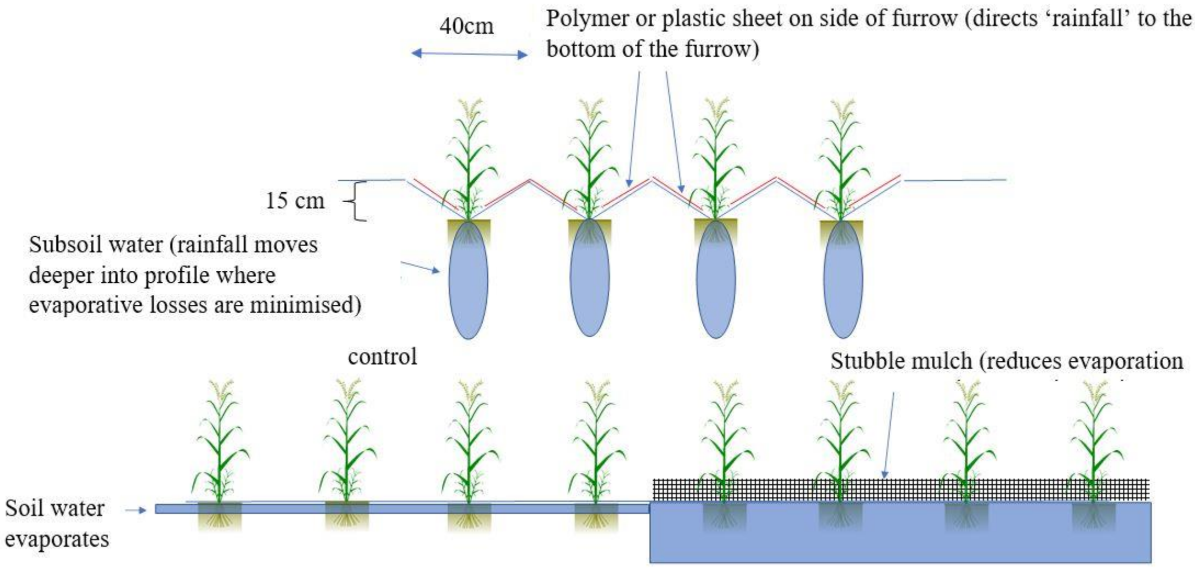

Figure 1. Conceptual framework for ridge furrow system where both wheat and lentil are sown at wider row spacing of 40 cm and plastic sheet and polymer applied on the ridge

To understand the importance of fallow management strategies for improving the rainfall use efficiency, a new field experiment has been initiated in 2021. In this experiment we are creating large episodic rainfall events using a rainfall simulator. The main idea is to simulate the increasing summer rainfall events under a future climatic scenario. We are simulating the rainfall events of different intensities and for this we are using the design rainfall data system (2016) available at Australian Government Bureau of meteorology to define the extreme rainfall events recorded in the Wimmera region (Table1) as it is the extensive database with more than 30 years of rainfall data and better estimates 2% and 1% annual exceedance probability (AEP) of rainfall.

Table 1. Estimated annual exceedance probability (AEP) of rainfall intensity and depth at given time (*Design Rainfall Data System (2016)*, 2020) for Longerenong, Victoria

	Annual Exceedance Probability (AEP)							
Duration	Rainfall Intensity				Rainfall depth			
(Minutes)	10%	5%	2%	1%	10%	5%	2%	1%
1	158	189	235	273	2.63	3.15	3.91	4.55
2	130	156	192	221	4.35	5.19	6.39	7.36
3	118	141	173	200	5.88	7.03	8.67	10
4	108	129	160	185	7.21	8.63	10.7	12.3
5	100	120	149	173	8.37	10	12.4	14.4
10	75.1	90.2	112	131	12.5	15	18.7	21.8
15	60.8	73	90.8	106	15.2	18.3	22.7	26.5
20	51.5	61.8	76.9	89.5	17.2	20.6	25.6	29.8
25	44.9	53.9	67	77.9	18.7	22.5	27.9	32.5
30	40	48	59.6	69.3	20	24	29.8	34.6
45	30.6	36.6	45.4	52.7	22.9	27.5	34	39.5
60	25.1	30.1	37.2	43.1	25.1	30.1	37.2	43.1

Rainfall intensity and depth obtained from the designed rainfall data system (2016), coupled with three consecutive days of total rainfall events >20mm from 1900-2021 (Figure 2) between December-April obtained from the BoM silo data (Longerenong, 79028) will be used to define the extreme rainfall events in terms of both intensity and quantity.

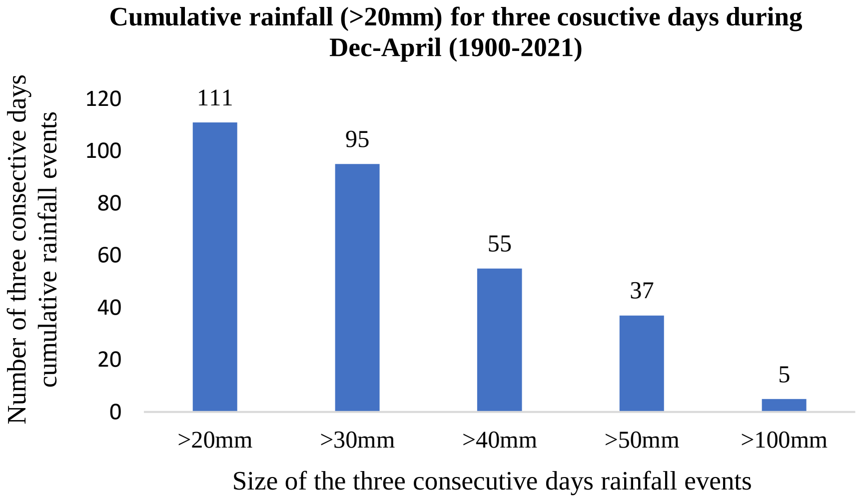

Figure 2. Cumulative rainfall(>20mm) for three consecutive days during Dec-April (1900-2021) for Longerenong, Victoria

Results

Preliminary analysis of experiment 1 showed higher yield for both wheat (8.5 t/ha mean grain yield averaged across treatments) and lentil (average of 6.5 t/ha across the treatments). However, there was no difference ($P = 0.05$) between treatments for yield of either wheat or lentils. Lack of statistical difference across the treatments possibly reflects the very high growing season rainfall (GSR = 287 mm; Decile 7) which provided plentiful soil moisture, confounded with poor control of weed prior to sowing which was visually worse in the corflute sheet and polymer applied plots. This experiment will be repeated in year 2021 where wheat will be replaced by lentil and vice versa. Provided the year

2021 is drier during the growing season we expect to see the effects of soil management treatments towards capturing the summer rainfall.

Conclusion

In the first year of experiment we could not find any significant difference in the yield of both wheat and lentil across the different soil management treatments and we believe it is mainly due to the due to good growing season rainfall as well as poor management of weed post irrigation. This trial will be repeated for the second year and simulated modelling will be carried out to validate the result.

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