Capture and use of water by wheat and chickpea in sole crops and intercrops, under dryland conditions of South Australia

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Abstract

In dryland regions such as the cereal zone of South Australia, the most limiting biophysical resource is water. Field experiments were conducted to quantify the use of soil-water and production of biomass in sole crops and crop mixtures in a study designed to evaluate the efficiency of intercropping in the use of this natural resource. Water-use and water use efficiency (ratio of biomass to water-use) for sole wheat were greater than for sole chickpea, but were similar for sole wheat and mixture. The land equivalent ratio showed no advantage or disadvantage of intercropping over sole crops. However, the water in the soil with the mixture was greater than the sole wheat. The presence of legumes in the mixture probably increased the N pool of the soil and might enhance the growth of the current and subsequent crops in an environment where the soil is poor in nutrient content.

Media summary

The study showed that intercropping was as efficient as sole wheat, while a greater amount of residual water and probably nitrogen in the soil in the intercropped plot improved fertility for the subsequent crop.

Key Words

Water use and water use efficiency.

Introduction

In dryland regions such as the cereal zone of South Australia, the most important and limiting biophysical resource is water. Many studies in semi-arid and monsoonal environments indicate that intercropping may increase and stabilise yield in water stress situations (Morris and Garrity 1993). In general there is a positive relationship between crop yield and the amount of water used during the growing season (French and Schultz 1984). Barker and Norman (1975) suggested that the better use of water is probably a common cause of yield advantages of intercropping systems in the semi-arid tropics. However, there have been few intercropping experiments in temperate Australia, and none has examined the role of soil-water in the performance of mixed crops, under the dryland conditions of South Australia. The objectives of this experiment were to (1) study the water relations in sole and mixed crops and (2) further evaluate the efficiency of mixed cropping in the use of water and in terms of the land equivalent ratio (LER).

Methods

The field experiments were conducted on the farm at the University of Adelaide Roseworthy Campus (latitude 34?32′S, longitude 138?41′E, elevation 68 m) during the growing season (May – November) in 1993 and 1995. The region has a Mediterranean-type climate. Measurements were carried out on selected plots comprising monocultures of chickpea and wheat and their binary mixture. The intercrop treatments were sown in single alternate rows in 1993 and double alternate rows in 1995. The seeding rates per plot for the intercrop treatment were half of those used for the monoculture sowing. Dry matter (DM) and grain were measured at the end of the growing season. The data on grain yield, dry mater production, water capture and use were collected from the 1995 experiment.

In 1993, soil water was measured along a 1.4 m depth of the soil profile at the end of the growing season by a gravimetric method, using a soil core sampler. In 1995, water stored in the 1.4 m depth root zone was determined using a neutron moisture meter at approximately fortnightly intervals. The crop water use or evapotranspiration (ET) was calculated from the changes in the storage of soil and rainfall using water balance method (Hillel 1971).

Results

The soil water content in 1.4 m depth of soil profile at the end of growing season is shown in Figure 1. Wheat had more water in the profile than sole chickpea, while chickpea had similar water content to the mixture in 1993.

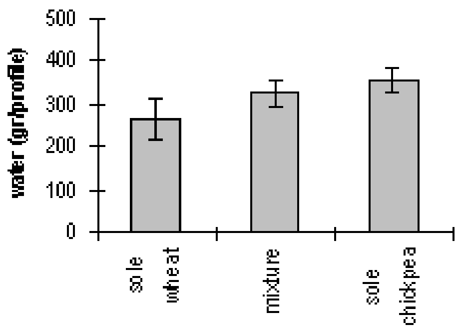

Figure 1. Soil water content in 1.4 m soil profile under wheat and chickpea in sole and in mixture using core sampler at the end of the growing season in 1993; the bars are standard errors of mean.

In 1995, the volumetric water content (θ) in soil profiles at early tillering (41 DAS) was similar for the three cropping systems. In all later dates chickpea had the wettest profile while wheat had the driest, and water content was always in the order of sole chickpea > mixture> sole wheat (Figure 2).

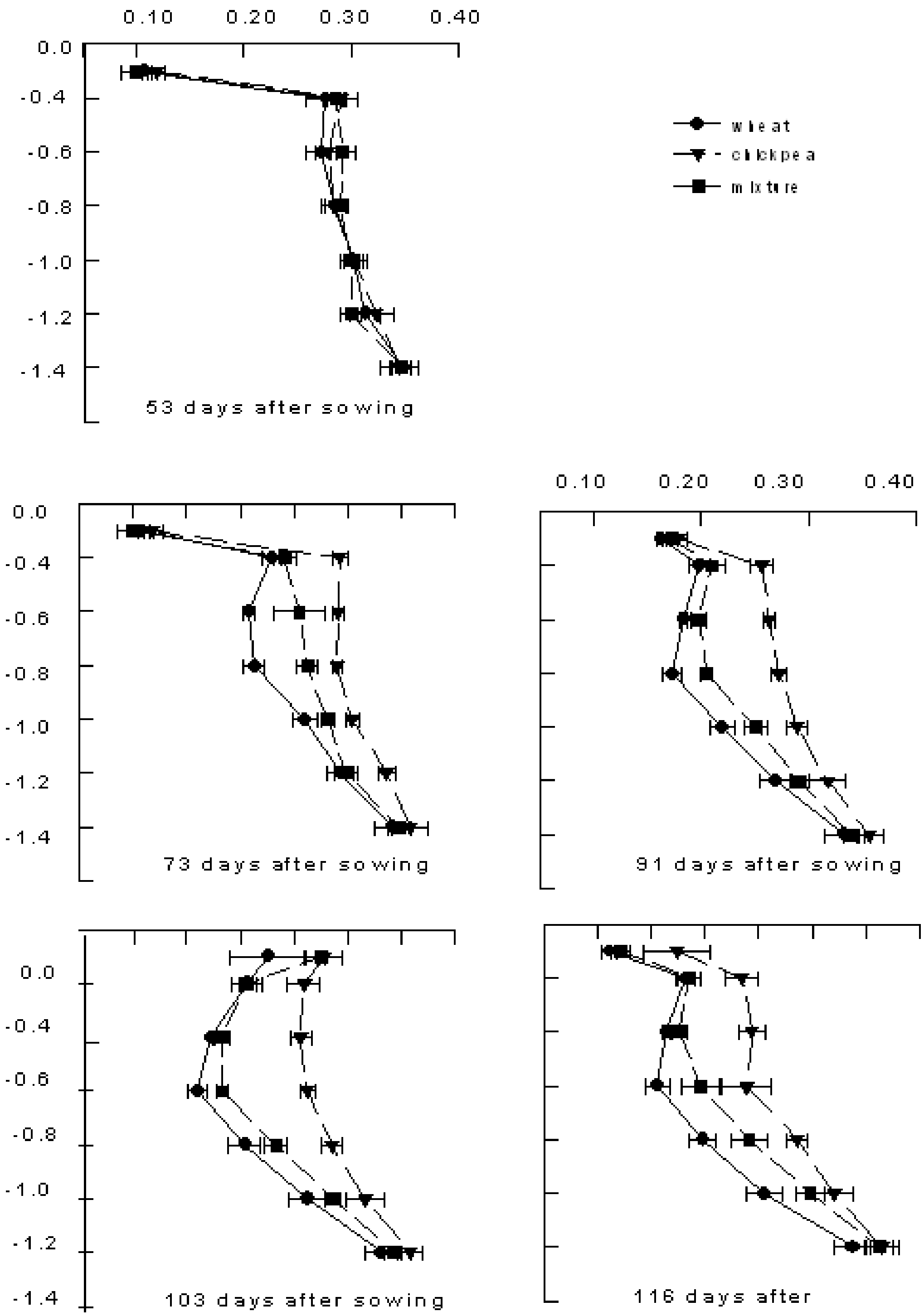

Figure 2. The volumetric soil water content (θ) in 1.4m soil profile under wheat and chickpea in sole and in mixture; the bars are standard errors of mean.

The ET during the growing season in 1995 for sole wheat was greater than for sole chickpea (Figure 3). ET of the mixture was similar to chickpea.

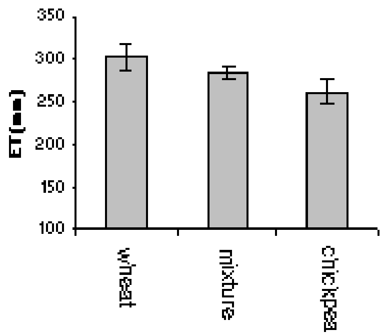

Figure 3. Evapotranspiration (ET) for sole crops and mixtures of wheat and chickpea; the bars indicate the LSD values.

Based on above ground DM produced, WUE was similar for both the mixture and sole wheat, both of which had greater WUE than the chickpea (Table 3). Water use efficiency based on grain yield (WUE_{grain}) for the mixture was about 16% higher than that for sole wheat, although this difference was not statistically significant. However, both sole wheat and the mixture had higher WUE_{grain} than chickpea (Table 1).

Table 1. Water use efficiency of grain yield (WUE_{grain}) and dry matter ($WUE_{biomass}$) of crops in different cropping systems.

cropping system	WUEgrain	WUEbiomass
Chickpea	9.4 b	2.6 b
Mixture	20.8 a	10.3 a
Wheat	20.4 a	8.6 a

Total dry matter produced by both wheat and chickpea in mixture was similar to that produced by sole wheat at 115 days after sowing. However, at the end of the season, dry matter for sole wheat was greater than that for the mixture, but the difference was only 30 kg ha^{-1} (Figure 4).

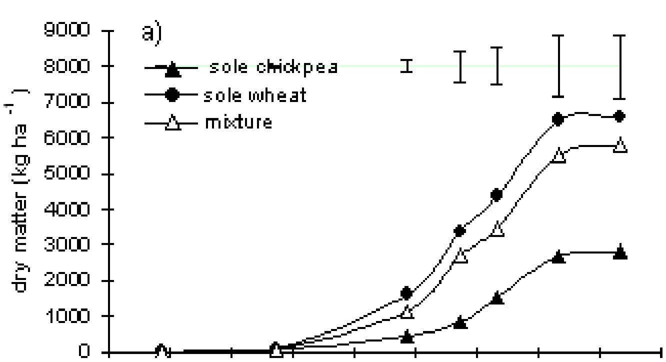

Figure 4. Cumulative dry matter (kg/ ha) for chickpea and wheat as sole and mixed crops; points showing the observed data with bars indicating the LSD values (P=0.05).

The LER is about 1 showing no advantage or disadvantage of intercropping over sole crops (Table 2).

Table 2. Yield (kg/ ha) of wheat and chickpea sole and intercrops and land equivalent ratios (LER)

Sole wheat	Wheat in mixture	sole chickpea	chickpea in mixture	Relative LER for wheat	Relative LER for chickpea	LER
3113?72	2202?156	801?154	242?27	0.71	0.31	1.01

Conclusion

Water use and water use efficiency for sole wheat were greater than for sole chickpea, while they were similar for sole wheat and mixture. The LER values showed no advantage or disadvantage of intercropping. However, the soil-water remaining in plots sown to a mixture of wheat and chickpea was greater than in plots sown to sole wheat. It was also possible that there were positive effects of intercrops on the N pool of the soil by which this resource was larger following a mixture of wheat and chickpea than following wheat alone (Jahansooz 1999). This might have a positive effect on the growth of subsequent crops. This outcome of legume-cereal intercropping is particularly important in dryland farming system of South Australia where the soils usually have low nutrient content.

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