

Irrigated maize in cotton systems

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Summary

Maize or corn (*Zea mays*) is becoming increasingly popular as a summer crop in irrigated cotton rotations. This is largely being driven by anecdotal grower evidence of yield improvements of up to 25 percent in cotton crops grown after maize compared to back-to-back cotton. Cotton growers believe that their soils are in better condition after a maize crop with higher amounts of organic matter observed compared with fields coming out of cotton or wheat. This improved soil structure is thought to be the main driver of the increased yields. Recent research has shown that maize provides more organic matter to upper layers of the soil and extracts less water at depth compared with cotton. It is thought that the following cotton crop can then benefit from increased water availability and better soil health. Another recent study showed that microbial biomass and root density are higher in cotton-based rotations that include maize compared with rotations with wheat or continuous cotton. Maize also provides a number of other benefits to cotton growers including reduced workload in the second half of the season compared with cotton, a refuge option as part of a Bollgard II resistance management plan and diverse marketing opportunities.

Research

For many years cotton growers have observed improvements in yields of cotton crops following a maize crop compared to those following back-to-back cotton. A grower in the South Burnett grew cotton that yielded 10 to 12 bales per hectare after two years of growing a maize crop compared to 7.5 bales per hectare in a nearby continuous cotton cropping system. Other growers at Dalby and Moree have also reported up to 25 percent increases in cotton yield after maize.

This anecdotal evidence led to a three-year Cotton CRC/University of Queensland research project being instigated to investigate the quantitative yield and economic benefits of maize in irrigated cotton-based cropping systems.

As part of this research in the 2007-08 season, a field experiment involving water stress was established at the University of Queensland, Gatton. Water was excluded from cotton and maize from either 24 days (prolonged water stress) or 65 days (short water stress) after sowing until maturity. Treatments were imposed using rain-out shelters for the water stress treatments and overhead irrigation when required for the unstressed cotton and maize control treatments. Soil moisture and root mass measurements were taken at regular intervals throughout the season.

At 92 days after sowing (DAS) soil water extraction was greater in cotton compared to maize at the 30-70 cm soil depth (Figure 1) despite cotton having lower root mass than maize from 65 DAS onwards (Table 1). This could be related to root structure differences between cotton and maize or because maize matures more quickly than cotton when the two crops are planted at the same time. The implication of this difference is that more soil water is available to a following cotton crop in fields coming out of maize compared to cotton. The increased root mass of maize may also lead to an increased number of macropores and so better soil drainage and water availability in the following cotton crop.

Figure 1. Soil water content of cotton and maize trial with prolonged water stress

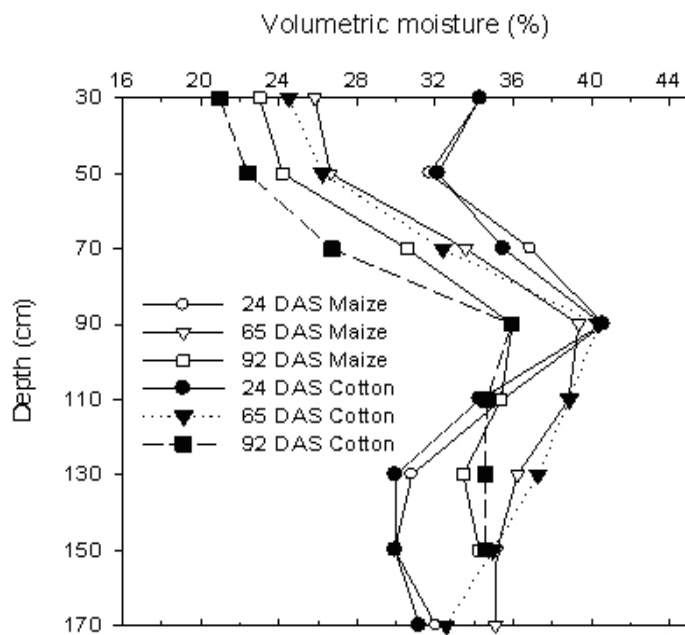


Table 1. Root mass of cotton and maize under water stress: water excluded from 24 and 65 days after sowing (DAS) until maturity (numbers in brackets are standard error)

	24 DAS		65 DAS	
	Maize	Cotton	Maize	Cotton
	kg/ha			
0-20 cm	95 (37.47)	393 (228.87)	1220 (534.49)	305 (161.78)
20-40 cm	60.10 (38.58)	139.80 (65.56)	391 (56.60)	141 (16.87)
40-60 cm	0 (40.49)	26 (15.44)	179 (22.86)	79 (50.78)
60-200 cm	82	15	82	92
Total	239	575	1875	619

As part of the long-term rotation trial at the Australian Cotton Research Institute, a study in the 2006-07 season examined the differences between soil organic carbon, carbon fraction and microbial biomass in four cotton-based rotations including maize.

There was a positive relationship between microbial biomass, root density and labile carbon (the fraction of soil organic carbon with most rapid turnover times). Microbial biomass increased as

root density increased ($R^2 = 0.70$) (Figure 2). Microbial biomass also increased as the soil labile carbon percentage increased as measured by light fraction of the soil organic carbon ($R^2 = 0.68$) (Figure 3).

Figure 2. Correlation between root density and microbial biomass in December 2006 ($P < 0.001$)

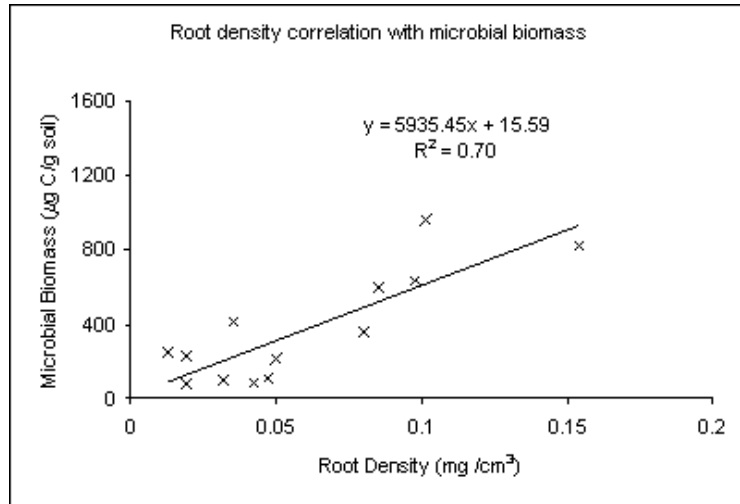
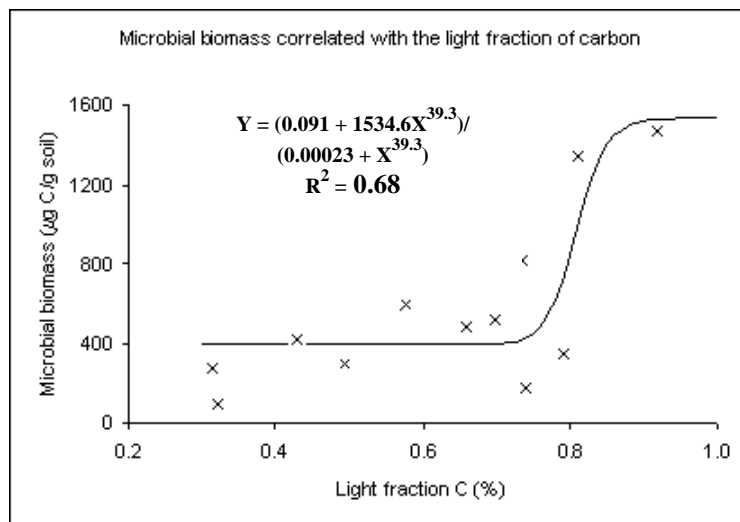


Figure 3. Correlation between microbial biomass and light fraction of soil organic carbon ($P = 0.04$)



Microbial biomass and root density were higher in the rotations that included maize (cotton-maize and cotton-vetch-maize) compared with cotton-wheat and continuous cotton rotations (Figures 4 and 5).

Figure 4. Microbial biomass for cotton-maize (CCo), cotton-vetch-maize (CVCo), continuous cotton (CC) and cotton-wheat (CW) rotations (graphs a and b are samples from 28/11/06 and graphs c and d are samples from 20/1/07)

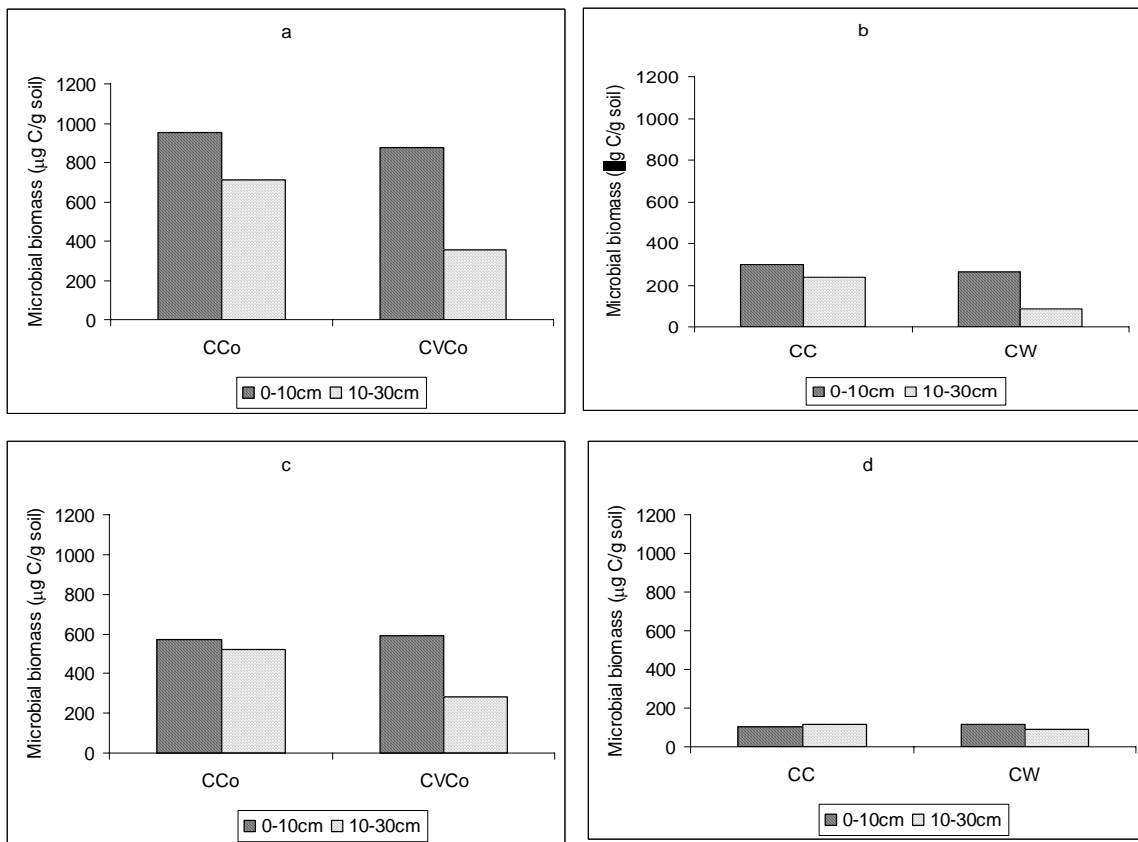
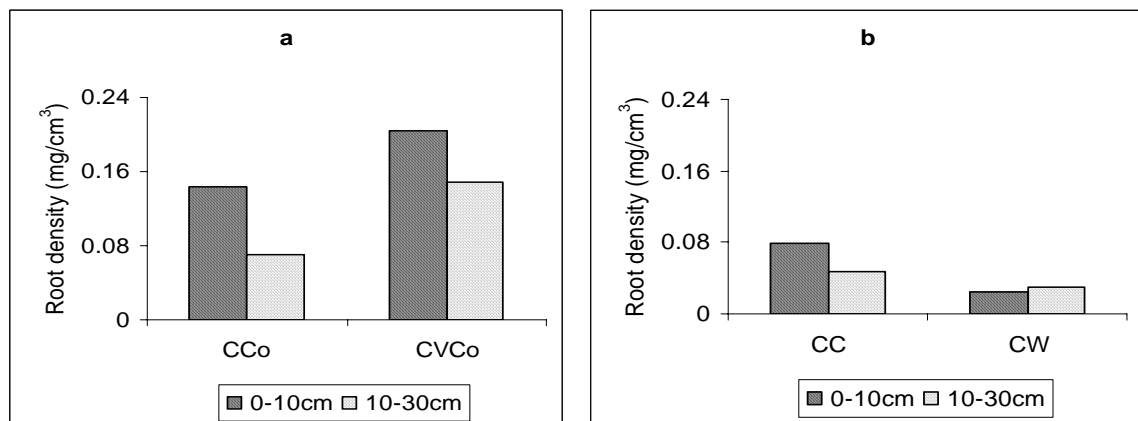


Figure 5. Root density from soil cores sampled on 15/12/06 for cotton-maize (CCo), cotton-vetch-maize (CVCo), continuous cotton (CC) and cotton-wheat (CW) rotations



It was thought that the greater root mass in the rotations including maize improved microbial biomass by providing a higher level of nutrients and living biomass. In addition, higher levels of biomass from maize provided more labile carbon. This could improve soil porosity and soil structure leading to improved root growth in the following cotton crop.

Results from the 2007-08 season in the long-term rotation trial demonstrate the yield benefits of rotations compared to continuous cotton (Table 2). A cotton crop following maize yielded close to seven percent higher than a cotton crop following cotton. The increased yield is less than expected perhaps because of insufficient water for the maize crop in the 2006-07 season. A well-grown irrigated maize crop should typically have a grain yield of between 12 and 15 tonnes per hectare. The yields in the trial in the 2007-08 season are from 4.4 to 6.4 tonnes per hectare, which is more typical of maize grown in a limited water situation.

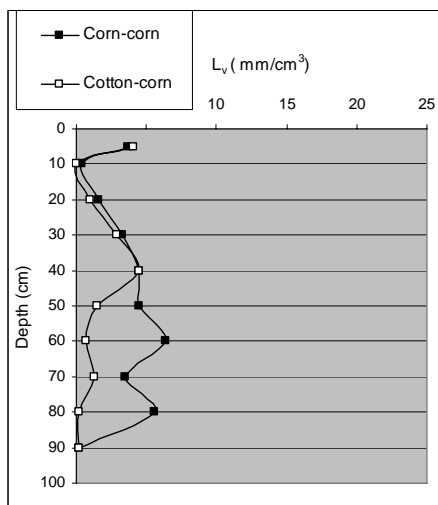
Table 2. Cotton and maize yields of three cotton-based rotations in the long term rotation trial at the Australian Cotton Research Institute, Narrabri (2007-08)

Treatment	Lint (bales/ha)	Lint (t/ha)
Continuous cotton	8.2	1.9
Cotton following maize	8.8	2.0
Cotton following wheat	8.8	2.0

Treatment	Total dry matter (t/ha)	Grain (t/ha)
Maize following cotton	6.9	4.4
Maize following maize	8.0	6.4

There was also a yield increase in maize crops grown after maize compared to cotton. This is probably related to differences in root growth between the two rotations, particularly at depth. Figure 5 shows root density for a maize crop following either maize or cotton. The lower root density below 40 cm in the cotton-maize rotation is likely to be because of a drier soil profile and higher soil strength from the previous cotton crop.

Figure 5. Root density (L_v mm/cm³) measurement of maize (corn) in early January 2008 in a maize-maize and cotton-maize rotation



A successful maize crop

A well-grown crop is essential to ensure the benefits that maize can provide in a cotton-based system. There are six important factors to growing a successful maize crop.

1. Understand the critical periods

There are several critical periods in the life of a maize plant but the most critical is between weeks five and eight after planting. During this period the plant is growing rapidly and has a high requirement for nutrients, water and sunlight. Any shortage of these inputs or damage to the reproductive structures will have a permanent negative effect on final yield. Maize ear size is determined at this time, firstly numbers of row per ear then number of kernel per row along per ear.

2. Ensure nutrient requirements are met

Nitrogen (N), phosphorus (P) and potassium (K) represent 83 percent of a maize plant's total-absorbed nutrients. So it is important to set a fertiliser program – especially for these nutrients – based on an expected yield goal. For instance, a 10 t/ha grain crop will require approximately 240 kg/ha of N, 50 kg/ha of P and 200 kg/ha of K.

3. Ensure adequate water management

Maize requires approximately 370 kg of water to produce one kilogram of dry grain weight. This compares to 560 kg of water for cotton plants to produce one kilogram of lint. The key water requirements of a maize plant can be split into the following: 20 percent for the first five weeks after emergence, 33 percent for the next three weeks (prior to silking) and 31 percent for the next three weeks during silking and grain fill.

4. Control weeds

Similar to cotton, weed control is very important in maize to ensure maximum yields. Grass weeds are the most competitive for light and moisture. But both broadleaf and grass weeds must be controlled early, particularly before the maize crop reaches about 0.8 metres in height. Mechanical and chemical weed control options are available.

5. Monitor and control insects if necessary

Maize crops are most susceptible to serious damage from insects during establishment (damage from soil-borne insects can mean resowing is necessary). Professionally-applied seed treatments play an important part in controlling soil insects, such as false wireworm and earwigs.

6. Chose the correct hybrid

The end-use of the maize will determine which type of maize hybrid a grower chooses, including stockfeed, processing (maize chips, maize flour etc), speciality types (waxy or high amylose) or silage. Some maize hybrids have dual or multipurpose end-uses. Maize hybrids are also rated for maturity by comparing the moisture at harvest to a hybrid of known maturity. This is called comparative relative maturity (CRM). Generally hybrids with low CRMs (90-100) are suitable for southern region, mid-range CRM hybrids (101-115) are suitable for central regions and the highest

CRM hybrids (116-125) should be grown in full season areas such as northern NSW and Southern and Central Queensland.

Other benefits

September- or October-planted maize will be mature in January. It will then require no more inputs until harvest allowing growers to concentrate on managing cotton or other crops. The husk covering the cob protects the maize kernels from weather-induced damage giving an extended harvest-window once the crop has dried down.

In addition, after the maize has matured in January, any in-crop rainfall will not be used by the crop and will be available as soil moisture for the following crop.

Once a maize crop has emerged, the main insect pest is *Helicoverpa armigera*. But this pest rarely causes economic damage so insecticidal control is seldom needed. So if maize is planted at three times though the season (for example, September, November, January), it can provide a consistent supply of *H. armigera* moths and act as an effective refuge area as part of a Bollgard II resistance management strategy.

Maize also provides diverse marketing options to growers. Forward contracts are available for all end uses of maize.

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