Unique root mass in Australia's rice

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ABSTRACT

Japanese and Australian rice cultivars of varying maturity were grown at Yanco, NSW, in a replicated field trial during the 1998/99 and 1999/2000 seasons. The trial included a total of eleven lines that were sampled fortnightly for above-ground and root biomass. Root weight increased in all lines prior to flowering. A positive relationship existed between maximum root weight and days to flower across both years. YRL118 (an advanced Australian long grain line) produced the greatest root weight (468 g/m^2) in both seasons. Maximum root weight across the 2 years remained unchanged irrespective of the larger above-ground biomass in the warmer 1998/99 season.

KEY WORDS

Rice, roots, growth pattern.

INTRODUCTION

The aim of this research was to determine the seasonal pattern of root accumulation for a range of cultivars in a high yielding environment.

The determination of root weight is required to calculate the efficiency of converting solar radiation into biomass. Often root weight is estimated as a percentage (ie 10%) of the weight of total above-ground biomass at anthesis (Kiniry *et al.* 1989). This estimation poorly predicts root weight and does not account for genotypic variation.

Recent observations of root weight in temperate rice crops in Australia have recorded maximum root weight of 400 g/m^2 (Williams *et al.* 1998). In comparison, temperate varieties from Japan have recorded far lower root weights.

During the seedling and tillering stages in rice, root weight increases, but is reduced after anthesis due to less leaves to provide the assimilates (Beyrouty *et al.* 1988). Australian rice varieties have been found to follow similar trends (Farrell *et al.* 1999). The growth of roots increases with the growth of above-ground biomass until anthesis occurs after which root production slowly decreases. Phenotypic growth patterns of different cultivars are important for the determination of how and when assimilates are allocated to roots and how climatic changes affect root growth. This paper investigates the patterns of above-ground and root growth of Australian and Japanese rice varieties.

MATERIALS AND METHODS

A combination of rice varieties from temperate rice producing countries, cultivars ranging in growth duration's and a mixture of semi-dwarf and tall varieties were included in the 2 years of experimentation

For both years, rice plants were established at Yanco Agricultural Institute (Lat. 33.5^{o} S, Long. 146^{o} E). The plots were 20 m long and 1.4 m wide, with 7 rows, 20 cm apart. Varieties were drill sown at a planting rate of 120kg/ha on October 3, 1998 and October 7, 1999. Plots were irrigated intermittently until mid-November when permanent water was applied. Prior to permanent flood, nitrogen was applied onto the dry ground and irrigated into the soil. The date of anthesis was recorded when 50% of spikelets had dehisced anthers in at least half the panicles.

Table 1. Varieties grown in this study based on origin, length of season and grain type.

Variety	Origin	Duration (Days to flowering)	Grain type	Plant height
Amaroo	Australia	130	Medium	Semi-dwarf
Millin	Australia	117	Medium	Semi-dwarf
Jarrah	Australia	107	Medium	Semi-dwarf
Pelde	Australia	120	Long	Tall
YRL118	Australia	122	Long	Semi-dwarf
YRL39	Australia	126	Long	Semi-dwarf
Koshihikari	Japan	125	Medium	Tall
Akitakomachi	Japan	120	Medium	semi-dwarf
M7	California	132	Medium	Semi-dwarf

Above and below-ground biomass samples were randomly taken every 2 weeks. Measurements for above-ground dry matter production were sampled using a quadrat of 0.5 m^2. Samples were taken from the inner five rows at the soil surface from each of the three replicates. Roots were then sampled from the soil within each quadrat from two cores placed midway between the drill rows. The cores were collected with a circular stainless steel tube (10 cm in diameter and 10 cm long), with a 1.5 mm wall thickness and a sharpened cutting edge. The top of the tube was attached to a vertical shaft with a horizontal handle, which was rotated to cut the soil and roots to the sampling depth. The corer was tilted slightly to break the suction and a hand inserted into the soil to prevent the core from falling out of the corer as it was removed. The cores were frozen until ready for processing, when they were thawed, and the soil washed from the roots. The process of root washing consisted of placing the core in a steel tray with 2 mm holes and hosing gently with a water jet. After most of the soil was washed away, the mat of roots was placed in a 20 cm diameter soil sieve with a 1 mm mesh. There the roots were repeatedly hosed, submerged in water, and agitated while still in the dish. To ensure that no roots were lost in the process, a second dish with a 0.5 mm mesh was placed below the first dish. The quantity of roots reaching this dish was negligible. The resultant mass of cleaned roots was dried and then tapped with a hammer to remove any remaining soil. The shoots and roots were dried at 80? C for 48 hours and then weighed.

RESULTS

The 1.6^{o}C cooler maximum temperatures of the 1999/2000 rice season restricted the growth of the above-ground biomass compared to 1998/99. In the 1999/2000 rice season above-ground biomass at maturity was reduced by 4 tonnes for YRL118 and Jarrah and 7 t/ha for Amaroo compared to the 1998/99 rice season (Figure 1). However, there was little to no effect on the root production throughout the season or at maturity (Figure 2).

All varieties displayed similar patterns of above-ground growth during both seasons. A Spline curve was fitted for above-ground biomass and tested for variety differences. There were significant differences between varieties for above-ground biomass, but there was no interaction between variety and time of sampling. The longer duration lines produced a greater biomass than short duration lines at the end of the season due to their longer growth period. The maximum above-ground biomass was recorded in Amaroo of 2500g/m^2.

However, there was a significant interaction between variety and sample time for root weight in both years. In the 1998/99 season, root weight increases slowly until mid-December, then increased rapidly until just prior to flowering.

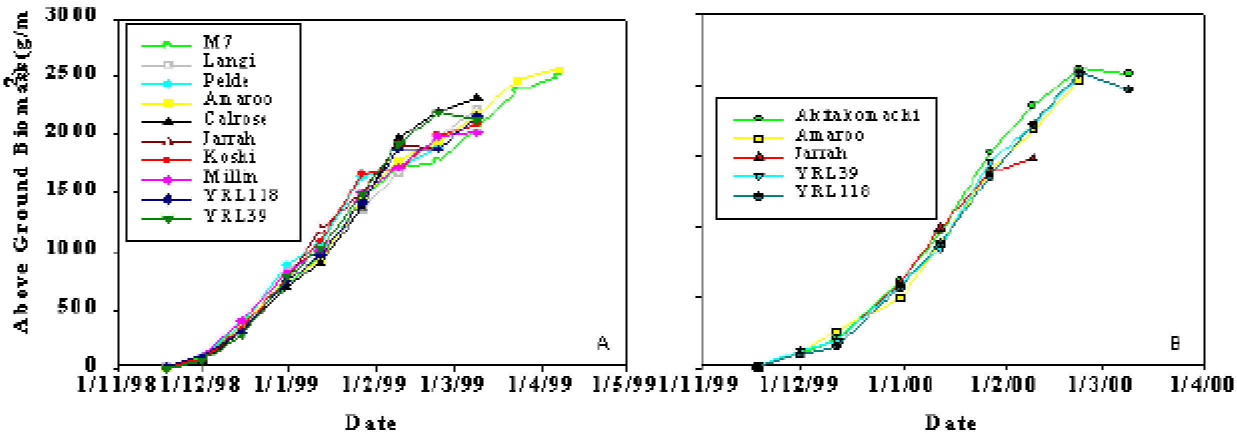

Figure 1. Above-ground biomass for a range of rice lines in 1998/99 (A) and 1999/2000 (B) rice season.

The long grain cultivars YRL118 and YRL39 exhibited rapid growth up to anthesis (468 and

430g/m^2 respectively) followed by a sharp decline (228 and 242g/m^2) in the 1998/99 season. Similar trends occurred in the 1999/2000 season, as YRL118 reached a peak of 463.6 g/m^2 root mass at anthesis, before reducing to 302.6 g/m^2 by harvest. Amaroo produced a large root mass of over 450 g/m^2 for both seasons, far exceeding Japanese rice varieties Koshihikari and Akitakomachi (297g/m^2 and 274 g/m^2 respectively).

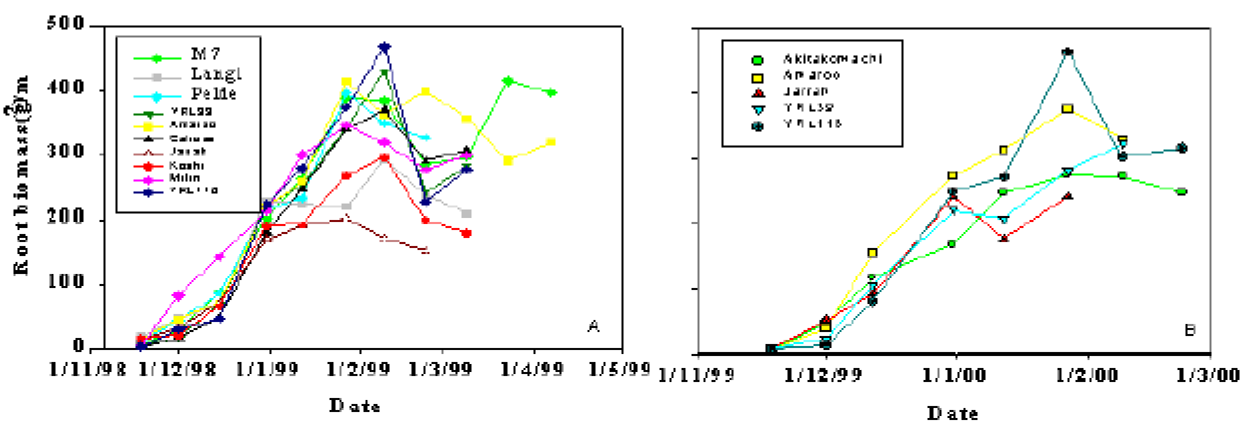

Figure 2. Root production for a range of rice lines in 1998/99 (A) and 1999/2000 (B) rice season.

DISCUSSION

The pattern of root growth reaching a maximum approximately two weeks prior to flowering, and then remaining constant is similar to those reported in Arkansas (Beyrouty *et al*. 1988) and Kang (1994). However, the large root weights recorded for paddy rice is much larger in Australia than that recorded for temperate rice in other locations. Japanese research typically reports maximum root weights of 50-100 g/m2 (Kang *et al*. 1994). The same variety in this experiment (Koshihikari) produced 283 g/m2 of root weight at flowering.

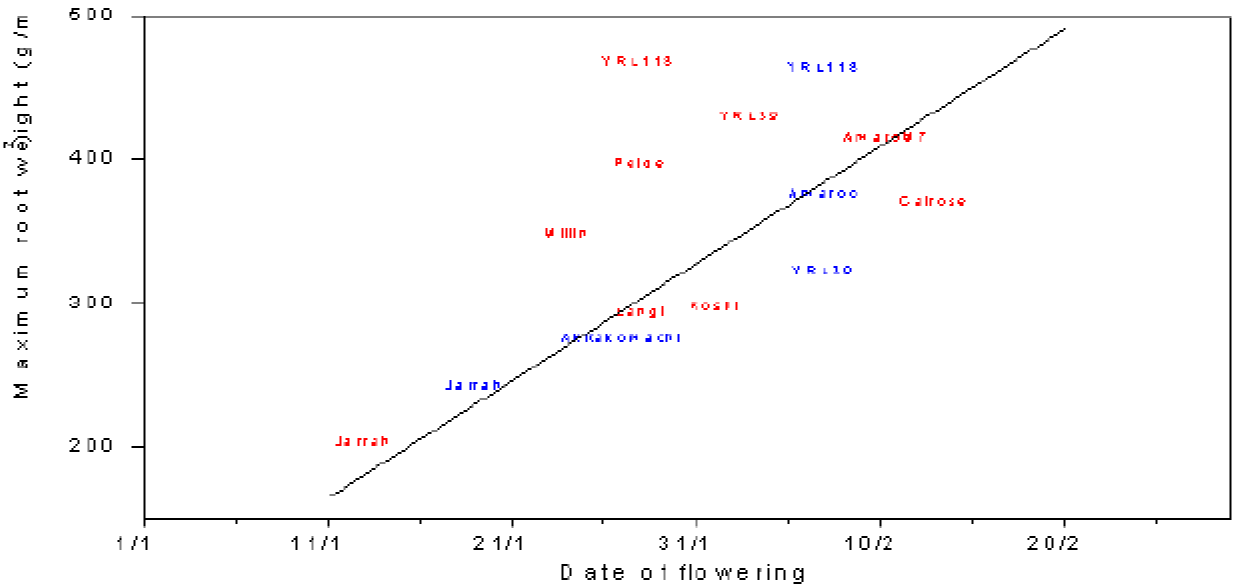

Figure 3. Maximum root weight versus date of flower for a range of rice varieties for 1998/99 (red) and 1999/2000 (blue).

The pattern of above-ground biomass accumulation was similar across all varieties, with the exception of short season varieties that stopped growth earlier than the longer duration varieties. As a result, there was a significant relationship between maximum root weight and date of anthesis (Figure 3).

A significant spike in root weight was observed in line YRL118 in both years. In 1998/99 YRL118 and YRL39 had a longer root growth phase than most other varieties, which was followed by a dramatic reduction in root weight. These two lines have been known to suffer from the physiological disorder of straight-head, which includes symptoms of malformed florets. It is hypothesised that the susceptibility of these lines to staight-head is associated with the unique patten of root growth of these lines.

Higher temperatures in the 1998/99 season led to higher above-ground biomass. However in contrast to Beyrouty *et al*. (1988) findings root weight did not increase.

CONCLUSION

The pattern of root growth throughout Australia is similar to that reported in other temperate rice growing regions. However the root weight recorded is much greater than other locations.

ACKNOWLEDGMENTS

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