Skip sorghum when and where should it be used?

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Abstract

In recent years many sorghum producers in the more marginal (<600 mm annual rainfall) cropping areas of Qld and NNSW have utilised skip row configurations in an attempt to improve yield reliability and reduce sorghum production risk. But will this work in the long run? Under what conditions is the use of a skip row configuration the optimal choice?

This paper describes long-term simulations conducted on soils of different water holding capacities (PAWC) and with 3 different initial starting water conditions. The results show an interaction exists between starting water conditions and soil (PAWC) that suggests crops grown on soils with a low water holding capacity benefit from the use of skip configurations.

Media summary

The decision to use a skip row configuration should be based on soil PAWC, soil water status at sowing and adversity to risk.

Key Words

Simulation modelling, row configuration, sorghum

Introduction

Sorghum crops in NE Australia are grown on a common row spacing of 1m and this is generally referred to as solid configuration (Fig. 1a). To reduce risk and improve yield reliability, two other configurations are often used. These are: single skip, where two rows are planted 1m apart and every third row is skipped leaving a 2m gap between twin rows (Fig. 1b) and double skip, which is similar to single skip, but every third and fourth row are skipped leaving a 3m gap between twin rows (Fig. 1c). Other row configurations are used in the sorghum growing areas of NE Australia, however, the configurations discussed in this paper will refer to those most commonly used; “solid”, “single”, and “double”.

This paper describes long-term simulations comparing risks for different sorghum row configurations when established under different starting conditions and on soils with different plant available water holding capacities (PAWC).

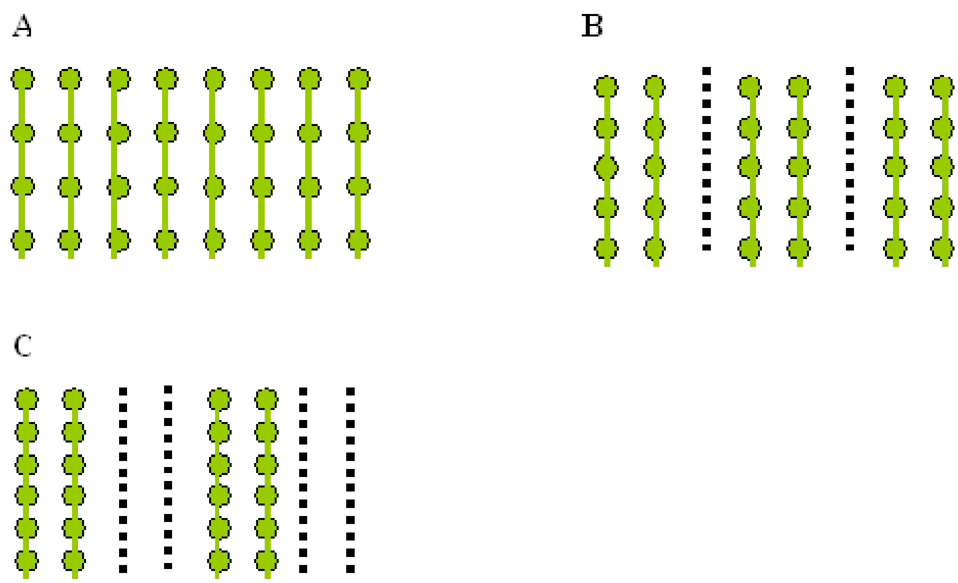


Figure 1. Diagrammatic representation of a range of alternative row configurations used for sorghum production. Solid lines represent rows with plants present while dotted lines represent skipped rows. (A) solid configuration, (B) Single skip, (C) Double skip

Methods

Long-term simulations were conducted for 6 experimental sites described by Butler *et al.* (2001), Routley *et al.* (2003), McLane *et al.* (2003) each using meteorological data from the nearest met station (Table 1). The starting water for each site was varied as a fraction of PAWC giving simulations a starting soil water of 30, 60 and 90 percent, each year at each site. Soil nutrients were set to be non-limiting and the sowing date was standardised on the 15 of November in all years. For consistency the sowing density was the same at each site (75,000) plants/ha and the number of fertile tillers set to 1, 0.5, and 0 for the solid single and double row configurations respectively.

Table 1. Initial parameters used for long term simulations.

Site		Row spacing (m)	PAWC(mm)	Starting water mm	Starting nitrogen (kg/ha)
Billa Billa	1/3	1	201	80.4	201.06
	2/3	1	201	160.8	201.06
	Full	1	201	198.5	201.06
North Star	1/3	1	238	79.4	201.55
	2/3	1	238	158.8	201.55

	Full	1	238	235.1	201.55
Bungunya	1/3	1	202	67.4	199.1
	2/3	1	202	134.8	199.1
	Full	1	202	198.7	199.1
Moree	1/3	1	234	77.9	199.96
	2/3	1	234	155.8	199.96
	Full	1	234	231.2	199.96
Boggabilla	2/3	1	178	59.4	199.9
	2/3		178	118.8	199.9
	Full	1	178	174.2	199.9
Meandarra	1/3	1	133	44.4	201.5
	2/3	1	133	88.9	201.5
	Full	1	133	131.4	201.5

The long term simulations were designed as a factorial experiment with starting water as one factor, row configuration as a second factor and the 100 year simulation as replication. This design enables the yield outputs to be analysed by analysis of variance to assess the interaction between starting water and row spacing.

Statistics

Statistical analysis was conducted using the linear regression and analysis of variance routines of the statistical software package R version 1.61 (Hornik 2002)

Results

Starting soil water and row configuration (skip) both significantly affected final yield at each site. At four of the six sites an interaction occurred between starting water and skip configuration. The two sites that did not show a significant interaction between starting water and row configuration were the two sites with the lowest PAWC (Table 1). The lack of interaction at these sites is a result of the limited soil water holding capacity, which restricted the potential yield of the solid crops with 90 % starting water. The difference between double and single skip crops with 90 % starting water on shallow soils is less than the equivalent difference on soils with a higher water holding capacity (Fig. 2). Yield in solid configuration is much higher than either the double or single skip configurations on soils with 238mm PAWC and single and solid yields are similar when sown with low starting moisture.

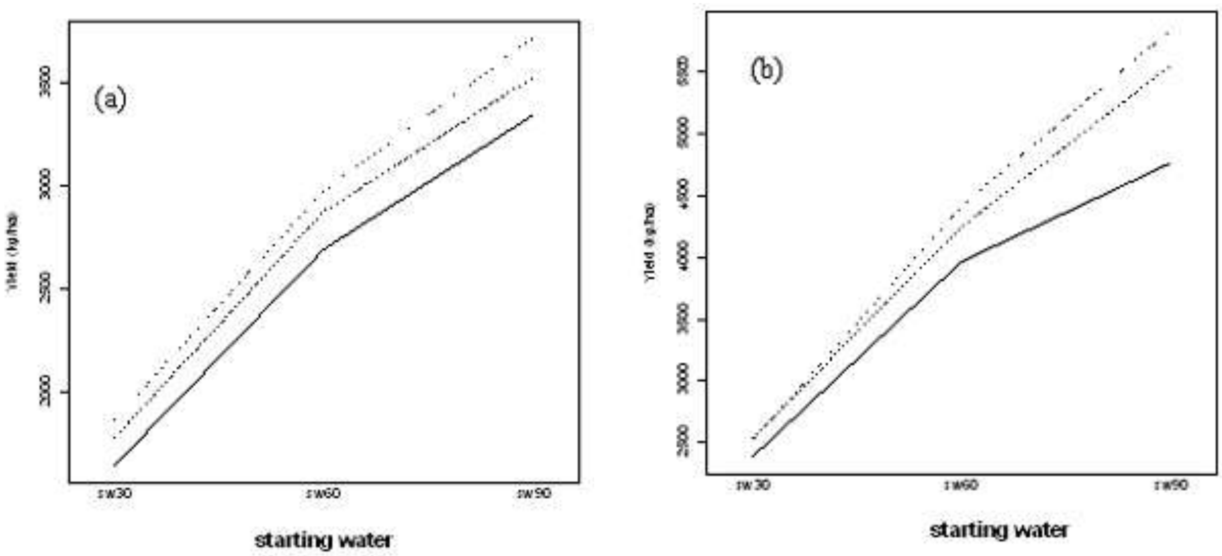


Figure. 2. Interaction plots for Meandarra (a) 135mm PAWC and North Star (b) 238mm PAWC. For the three skip configurations (…….) solid, (-------) single and (____) Double.

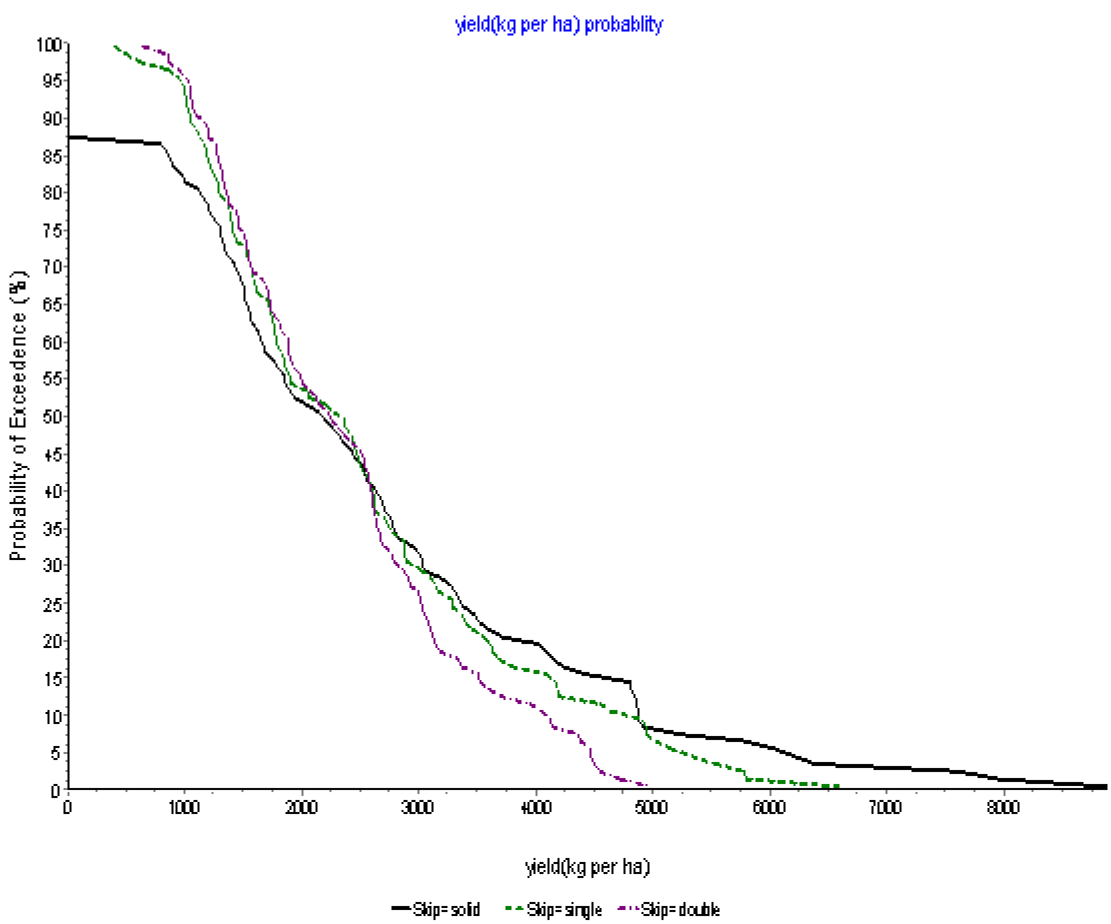
The long term mean simulated yield of crops grown in a solid configuration over a range of starting moistures is higher than the average of double skip, and higher than or equal to single skip (Fig 2). However, the average values mask the results for individual occasions when row configuration influenced the success of the crop. The simulations conducted with low starting water highlight the value of the skip configurations by enhancing chances of finishing the crop. Of the 100 years simulated with 30% starting water the skip configurations successfully matured 17 more crops than the solid configuration. Further when comparing the skip configurations to solid, it is important to determine how often a skip crop will out yield a solid crop while on average the solid configuration will out yield skip crops (Fig 2). There were numerous years that yield from skip configurations were greater than or equal to the solid yield (Table 2). The influence of starting water and soil water holding capacity is important, but in general with between 30-60 % soil water holding capacity available at planting skip will out yield solid, 50 % of the time. If the profile is 90% full at sowing and the soil has a PAWC greater than 200 mm then the ratio of skip over solid shifts from 50-50 to approximately 40-60. Crops produced in a skip configuration will out yield solid crops 50% of the time, but the long-term average yield is greater for solid crops. This difference occurs because solid crops have a higher yield potential and the magnitude of the difference between solid and skip crops in good seasons is what shifts the long-term average in the favour of the solid configuration.

Table 2. Percentage of crops where skip configuration out yielded or equalled solid row configuration for the three starting water conditions at each site.

Skip	Double			Single		
Starting Water	30 %	60 %	90 %	30 %	60 %	90 %
Billa Billa	47	40	17	58	49	39

North Star	52	51	31	62	54	49
Bungunya	44	46	36	56	49	44
Moree	61	58	30	68	59	45
Boggabilla	42	50	50	49	49	54
Meandarra	41	46	49	52	52	50

Production of sorghum in a skip arrangement sacrifices crop yield to reduce the risk of crop failure. Examination of yield probability of exceedence graphs shows a narrow yield range for double skip crops and a broader range for the solid crops from simulations with a PAWC of 200 mm (Fig. 3a). While there is significantly reduced chance of exceeding a high yield with double skip crops, there is also significantly greater chance of exceeding low or break-even yield levels. In soils with a PAWC of 130 mm the differences between the skip treatments and the solid treatment were reduced (Fig. 3b). However, the skip treatments never have a failed crop, whereas there were 17 in the solid treatment.



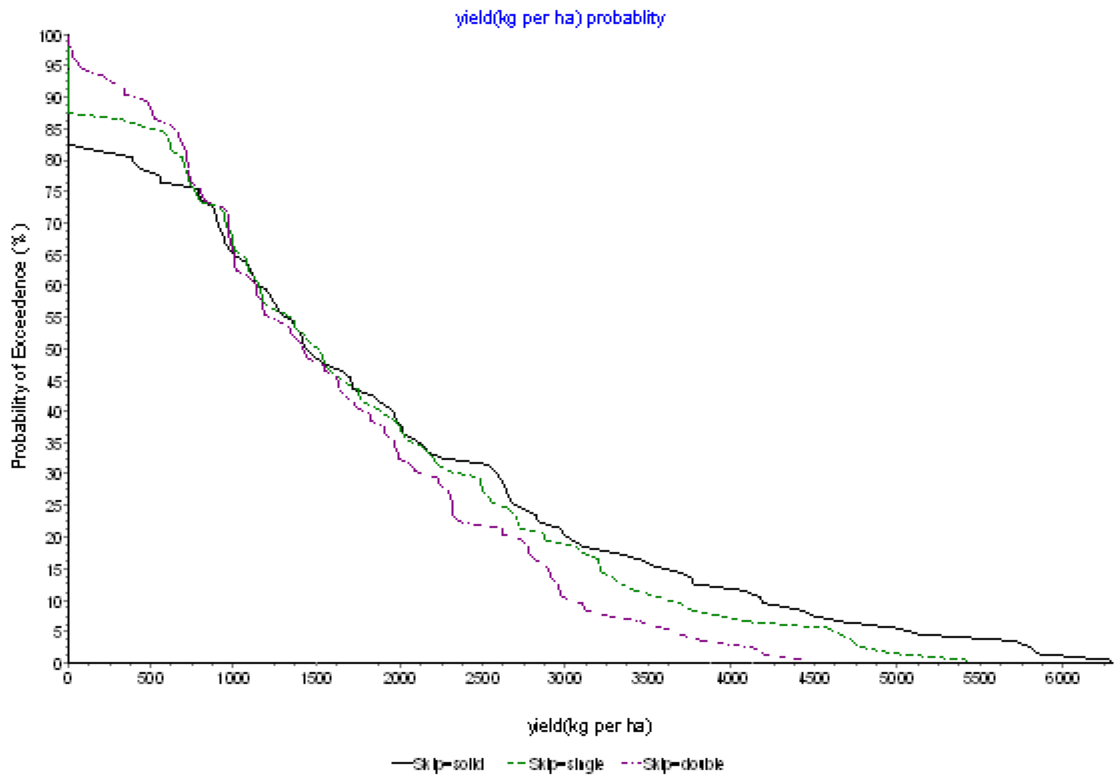


Figure. 3(a). Probability of exceedence for simulated crop yields from Croppa creek with a starting water of 30% and (b)Probability of exceedence for simulated crop yields from Meandarra with a starting water of 30%

Conclusion

The use of double or single skip configuration improves the yield reliability of sorghum by reducing failures (Table 2, Blum 1976; Wade *et al.* 1991). The long-term simulation analysis highlighted the fact that sorghum yield in the northern cropping region is strongly influenced by starting soil water. The skip treatments displayed a significant interaction with the soil water treatments for those sites where the soil PAWC was greater than 200 mm. In the shallower soils with lower water holding capacity, yield of the solid crops was constrained and the potential yield was lower, reducing the difference between solid and skip configurations.

The initial starting water is a good indicator as to how risky crop production will be in a specific year. Long-term simulations showed that if the soil has a PAWC of greater than 200mm and the profile is 90 % full, the risk of a failed crop is low, and a solid configuration will maximise yield potential with minimal risk. On the soils with a lower PAWC (130 mm) and 90% starting moisture the risk of crop failure is also low, but the yield potential of a solid configuration is not substantially greater than for the skip configuration. In this situation the potential yield loss by choosing a skip configuration is far less than for a higher PAWC soil.

Starting the soil with a 30% full profile significantly reduced the yield potential for both solid and skip configurations (Fig. 2). On the higher PAWC soil the skip configurations were dominant with yields of approximately 2.5 t/ha, there was then a yield interval between 2.5 and 5 t/ha in which the solid and single skip configurations out yielded the double skip crop. The solid crop was dominant for 10% of the time at yield levels in excess of 5 t/ha (Fig. 3a). The differences between the skip and the solid configuration under low starting water conditions were smaller, except at the extremes of the yield distribution (Fig 3b). Notably, however, the difference in successful crops was large with 17 (approx 1 in 5) solid crops failing.

References

Blum A and Naveh M (1976) Improved water-use efficiency in dryland grain sorghum by promoted plant competition. *Agronomy Journal* **64**, 775-778.

Butler GJ, Cawthray S, Castor M, Yeates S and Christian T (2001) Improving the reliability of sorghum production in the farming system. In Proceedings of the 10th Australian Agronomy Conference. Hobart 2001. (The Australian Society of Agronomy).

Hornik (2002) ‘The R FAQ’, http://www.ci.tuwien.ac.at/~hornik/R/ (ISBN 3-901167-51-X.)

McLean G, Whish J, Routley RA, Broad I and Hammer GL (2003) The effect of row configuration on yield reliability in grain sorghum. II. Modelling the effects of row configuration. In ‘Proceedings of the 11th Australian Agronomy Conference. Geelong 2001’. (The Australian Society of Agronomy)

Routley RA, Broad I, McLean G, Whish J and Hammer GL (2003) The effect of row configuration on yield reliability in grain sorghum. I. Yield, water use efficiency and soil water extraction. In ‘Proceedings of the 11th Australian Agronomy Conference. Geelong 2001’. (The Australian Society of Agronomy).

Wade LJ, Myers RJK and Foale MA (1991) Optimising plant stand in response to climatic risk. In ‘Climatic Risk in Crop Production: Models and Management for the Semi-arid Tropics and Subtropics’. (Eds RC Muchow, JA Bellamy) pp 263-282. (CAB International, Wallingford).