Seeding rate responses of new durum cultivars in Southern Australia.

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Abstract:
In South Australia, durum wheat growers have welcomed the introduction of several new varieties in recent years. Preliminary evaluation indicates the varieties have much improved yield potential, but exhibit large variation in grain size which may lead to more frequent quality downgrading from any potential stress during grain fill. It was hypothesised that high seeding rates (>200 seeds/m^2) commonly practised in commercial crops may also be detrimental to grain size for the new varieties. Over three years (2009-11), eight field experiments in the South Australian durum growing regions investigated the response of grain yield and quality to changing seed rate among durum varieties grown under rain-fed conditions. Across all experiments, there were no significant differences in variety response to seeding rate implying that current varieties exhibit a high similarity for response to input levels. Across all varieties, the overall effect of altering seeding rate depended mainly on interactions with the environment. Unexpectedly, seeding rate had no significant effect on grain yield or quality during harsh grain filling conditions (heat stress) but in more favourable, higher yielding environments, higher seeding rates (200–250 seeds/m^2) consistently yielded higher across all sites. Grain protein levels were reduced at higher seeding rate but all other quality parameters were unaffected. This research indicates that durum growers should manage new varieties as they would older varieties. We conclude that there is no likely benefit in lowering seeding rates and that seeding rates should be maintained at 220 seeds/m^2 to maximise yield and quality in the varieties evaluated here.

Key Words
Durum, wheat, seeding rate, plant density

Introduction

In South Australia, durum wheat growers have welcomed the recent introduction of several new varieties, which set a new yield performance benchmark. National Variety Trial (NVT) data indicate improved yields of up to 25% above Tamaroi (previous yield standard in SA) are possible, however the new varieties exhibit large variation in grain size, which can increase the chance of quality downgrading from any stresses encountered during grain fill. Durum wheat typically attracts a premium over and above bread wheat, however this is only realised when Durum grade 1 or 2 quality are achieved. A number of the emerging durum varieties are being downgraded for high grain screenings, low protein, and low test weights more frequently than lower yielding varieties such as Tamaroi and Caparoi.

Industry is currently questioning the role that agronomic input factors, such as seeding rates, play in the yield and quality response of newer varieties. Compared to bread wheat, growers have typically used a 5-10% higher seeding rate for durums as it is generally accepted that the kernel size is larger, the tillering capacity is lower, and durum is an inherently poor weed competitor. Sowing rates range from 70 kg/ha in lower rainfall areas up to 120 kg/ha in higher rainfall areas of South Australia (Mayfield 1998, and Impiglia 2000), equating to a seeding density of 160-250 seeds/m2 (assuming 45 g/1000 grain weight).

Compared to older varieties, the parentage of newer durum cultivars has a wider bread wheat background resulting in more erect plant structures with reduced leaf area. Much of the improved yield performance has resulted from a change in yield structure. An increased tillering capacity has led to greater grain number/area, which has negatively influenced grain size (unpublished data, Porker). Sharma and Anderson (2004) outlined inherent low grain weight and increased grain number/area were two important factors that negatively influenced grain screenings in bread wheat.

Altering seeding rates is one method of changing the yield structure of a plant. Reports discussing the influence of seeding rate on small grain screenings in bread wheat have shown that the influence of higher seeding rates is likely to be negligible (Anderson and Sawkins 1997). There is currently no reported information about the effect of management such as seeding rate on the current durum cultivars in SA. This series of experiments were conducted to assess varietal differences in responses to seeding rates, and to test the hypothesis that high seeding rates (>200 plants/m2) commonly practised in commercial crops to achieve optimum yields may no longer be required and may in fact be detrimental to grain size in new varieties.

Methods

Over three years (2009-11), eight field experiments were conducted in the South Australian durum-growing regions to investigate the response of grain yield and quality to changing seed rate among durum varieties grown under rain-fed conditions. Field experiments were conducted at Frances in the South East (521 mm average annual rainfall, a.a.r.), and at three sites in the Mid North, Hart (349 mm a.a.r.), Turretfield Research Centre (TRC) (470 mm a.a.r.), and Tarlee (470 mm a.a.r.). The grain yield and grain quality receival standard parameters (grain protein %db, test weight kg/hL, grain screenings %) of durum varieties Tamaroi, Tjilkuri, Saintly, Hyperno, WID803, WID802, and Caparoi were compared from three replications of plots (17.3 m^2) sown at seeding rates ranging from 120–250 seeds/m^2. Field trials at Turretfield and Tarlee included an additional three sowing times and at Frances in 2011 two nitrogen treatments were included. A REML analysis of variance of data was conducted using GENSTAT. Differences in treatment means of $P<0.05$ were considered significant.

Results

Grain yield

There were no significant differences in variety response to seeding rate for grain yield within any of the eight experiments (Table 1). The combination of other management factors, sowing time and nitrogen timing also did not identify any varietal differences in response to seeding rate (Table 1). Across all experiments, individual varieties yielded significantly differently (Table 1), with WID803, WID802 and Hyperno consistently being the highest yielding (Table 3).

Table 1. Table of significant effects on grain yield across all sites and seasons, Var = Variety, SR = Seeding Rate, TOS = Time of Sowing, N = Nitrogen timing.

Site	Yield (t/ha)	Var	SR	Var.SR	Var.SR.TOS	Var.SR.N
2009						
Frances	3.24	***	NS	NS		
Hart	3.13	***	NS	NS		
Turretfield	4.01	***	**	NS	NS	
2010						
Frances	4.51	***	***	NS		
Hart	4.25	***	***	NS		
Tarlee	4.66	***	***	NS	NS	
2011						
Frances	4.02	***	**	NS		NS
Tarlee	5.77	***	***	NS	NS	

NS = not significant, *$P<0.05$, ** $P < 0.01$, *** $P < 0.001$.

Seeding rate had a significant effect on grain yield at sites where yields were greater than 4 t/ha (Table 1). In experiments where a seeding rate response was significant, optimum yields were achieved on average at 220 seeds/m^2 in all varieties. The largest response to seeding rate was recorded at Frances in 2010 where increasing seeding rates from 190 to 220 seeds/m^2 resulted in a 0.9 t/ha yield increase. The highest seeding rate of 250 seeds/m^2 resulted in increased yields at Frances in 2011 but otherwise yields were similar to 220 seeds/m^2 across all other experiments. Seeding rates <160 seeds/m^2 often resulted in a yield penalty (Fig. 1).

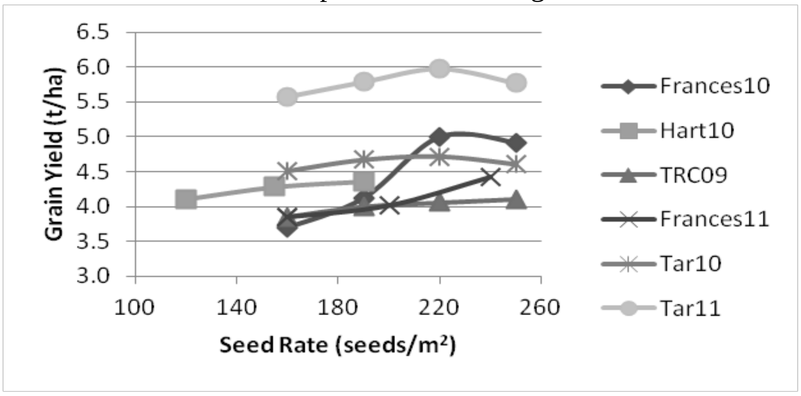

Figure 1. Grain yield response to seeding rate at sites and seasons (in key) averaged across all varieties (LSD $P<0.05$ = 0.11 t/ha).

Table 2. Table of significant treatment effects on Grain Screenings, Test Weight, and Grain Protein across all sites and seasons, Var = Variety, SR = Seeding Rate, TOS = Time of Sowing, N = Nitrogen timing.

Parameter	Site, Year	Range (site means)		Treatment factors				
							(TRC, Tarlee)	Frances
		Min	Max	Var	SR	Var.SR	Var.SR.TOS	Var.SR.N
Grain Screenings (%<2mm)	All sites, years	Hart 2009 0.82%	Frances 2009 10.8%	***	NS	NS	NS	NS
Test Weight (kg/hL)	All sites, years	TRC 2009 75.3kg/hl	Tarlee 2011 80.3kg/hL	***	NS	NS	NS	NS
Protein (at 11% moisture)	Hart 2010, Frances 2010 & 2011	Hart 2010 9.93%	Frances 2010 13.37%	***	**	NS	NS	NS
	Other sites, years			***	NS	NS	NS	NS

NS = not significant, *P<0.05, ** P < 0.01, *** P < 0.001

Grain screenings

Similarly, to grain yield, there were no significant differences in variety response to seeding rate for grain screenings, nor was there any effect of seeding rate on grain screenings across all sites and seasons. Inherent variety differences were the major factor influencing screenings across all sites and seasons (Table 2). WID803 has the highest screenings at an average of 3.9% in the Mid North and Caparoi on average less than 1% (Table 3).

Test weight

There were no significant differences in variety responses to seeding rate for test weight, nor was there any main effect of seeding rate on test-weight across all sites and seasons (Table 2). Inherent variety differences were the major factor influencing test weight across all sites and seasons. Test weight for sites in the Mid North ranged from 76.4 in WID802 to 79kg/hL in Caparoi (Table 3).

Table 3. The effect of variety on grain yield, grain screenings, test weight, and grain protein averaged across all treatment factors for sites in the Mid North of South Australia from 2009–11.

Variety	Grain Yield t/ha)	Grain Screenings (%<2mm)	Test Weight (kg/hL)	Protein (%db at 11% moisture)
Caparoi	4.42	0.9	79.5	13.3
Hyperno	4.98	2.8	77.0	12.1
Saintly	4.75	1.8	77.4	12.3
Tamaroi	4.46	1.7	78.1	13.1
Tjilkuri	4.87	2.4	76.3	12.2
WID802	4.91	2.8	75.5	12.0
WID803	5.17	3.9	76.8	11.7
LSD (P<0.05)	0.21	1.1	0.8	0.8

Grain protein

Varieties did not respond differently to seeding rate for grain protein at any site, however, the overall effect of seeding rate on protein averaged across all varieties was significant at sites which achieved high grain yield. Lower protein was observed at seeding rates that achieved maximum yield at Hart in 2010 and Frances in 2010 and 2011 (Table 2, and Fig. 1). Maximum yield was achieved at Frances in 2010 at 220 seeds/m^2 and resulted in the lowest protein due to the dilution effect of yield on grain protein (Fig. 2). Individual variety yield was inversely proportional to grain protein across all sites. The new higher yielding lines (WID803, WID802) consistently recorded lower proteins across all sites, Table 3).

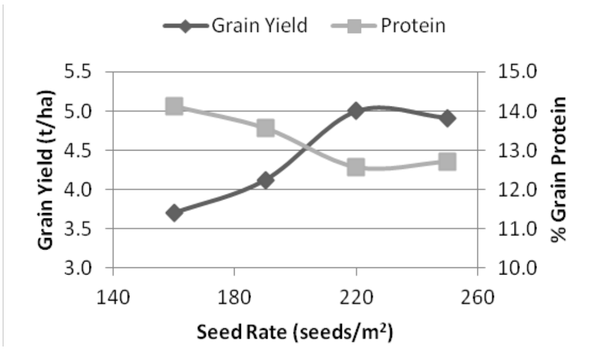

Figure 2. The effect of seeding rate on Grain yield (t/ha) and grain protein (at 11% moisture) averaged across all varieties at Frances in 2010 (Protein LSD ($P<0.05$) = 0.41%, Yield LSD ($P<0.05$) = 0.39t/ha).

Discussion

The key outcome from this study is that there were no significant differences in variety response to seeding rate for yield or any standard quality receival parameter. The lack of any difference implies the presence of a high inherent ability for compensation among yield components; hence, current varieties exhibit a high similarity for response to input levels. Across all varieties, the overall effect of seeding rate depended mainly on the interaction with the environment. In the more favourable environments there was a significant effect of seeding rate on grain yield when yields were >4 t/ha, with higher seeding rates (200–250 seeds/m^2) resulting in higher yield across all sites suggesting commercial seeding rates should remain above 200 seeds/m^2. Grain protein levels decreased at higher seeding rate but all other quality parameters were unaffected. Importantly, seeding rate had no significant effect on grain quality during harsh grain filling conditions (heat stress) experienced at Frances and Turretfield in 2009, when screenings levels were greater than 5%.

One critical factor determining the level of screenings, as outlined by Anderson and Sharma (2004), is the frequency of rainfall events towards the end of the season. However, during the vegetative and early reproduction phases, large variability in rainfall most likely limited yield potential, but almost all experiments received favourable rainfall during the grain-fill period. Accordingly, none of these sites experienced the extreme potential for high screenings that can be experienced in very dry seasons. This may have limited the ability of treatment affects to be established to the expected degree due to the narrow range in screening levels achieved across sites and seasons. Nonetheless, the lack of varietal interactions indicates growers can manage all varieties similarly. The overall outcome is consistent with work conducted in bread wheat, in that whilst seeding rate and seasonal conditions can affect wheat yield and quality to some degree, the net result is often most influenced by cultivar (Anderson and Sawkins, 1997). In environments where there is an increased risk of quality downgrading, varieties such as WID803 with inherently smaller grain should be avoided, instead favouring larger grained varieties such as Caparoi. Seeding rates should be maintained at 220 seeds/m^2 across all South Australian durum wheat growing environments.

Conclusion

This research indicates that durum growers should manage new varieties as they would older varieties. It may be concluded that variety choice is more important than seeding rate in managing grain yield and quality. There is no likely benefit in lowering seeding rates, therefore seeding rates should be maintained at 220 seeds/m^2 to maximise yield and quality in all varieties.

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