Plant density and nitrogen influences on wheat cultivars in Western Australia.

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Key messages

Within an environment, wheat cultivars did not differ in their yield response to a change in density or added nitrogen in a majority of trials conducted in 2015 and 2016.

Wheat plant densities of less than 100plants/m^2 will limit grain yields for cultivar's sown in early to mid-May. There is no consistent evidence that increased density to 200plants/m^2 will significantly affect grain yields or increase small grain screenings.

Maturity of the variety had a bigger influence on yield than density sown at the site which experienced frost damage.

Aims

The aim of the study was to assess cultivars for their responsiveness to management (plant density and nitrogen) and to determine if a different management practice might be required to maximise productivity. This study tested the hypothesis that cultivars in Western Australia differ in their yield response to increasing plant density and added nitrogen.

Method

Seven 'cultivar x nitrogen rate x target plant density' field experiments were conducted over 2 years (2015–16) at 7 sites in Western Australia (WA). The site details, rainfall and an estimate of potential yield at 80 and 110mm of evaporation for each experiment are shown in Appendix 1.

All experiments were sown in a split-plot design replicated three times with cultivar in main plots and nitrogen rate and target plant density in subplots. Plots were 10m long with 7 or 6 rows spaced 22 or 25.7 cm apart and were sown with a cone seeder with knife points. There were three target plant densities in each experiment. They were 60, 120 and 180plants/m^2 in 2015 and 60, 120 and 240plants/m^2 in 2016. Seed rates were calculated based on target density, average seed weight, germination percentage and establishment efficiency. The average plant densities established in 2015 were 50, 99 and 135 plants/m^2 respectively for the three target densities and 58, 116 and 201 plants/m^2 in 2016. There were six wheat cultivars sown each year. Mace^P and Corack^P were common to all trials in 2015 and Mace^P, Scepter^P and Emu Rock^P were common in 2016. Other varieties tested included Calingiri, Cutlass^P, Hydra^P, LRPB Trojan^P, Magenta^P, Supreme^P, Wyalkatchem^P, Yitpi^P and Zen^P. Four nitrogen rates were applied nil, 10, 30 and 50 kg/ha. Either nil or 10 kg/ha of nitrogen (applied as urea (46% nitrogen)) were top dressed at seeding and 20 or 40 kg/ha was applied at tillering as urea or UAN (32% nitrogen (w/w). In 2016, the nitrogen rates of 0, 10, 30 and 50 kg/ha were top dressed at seeding as urea and incorporated by the seeding operation. Superphosphate fertiliser (100kg/ha) was applied to each experiment at seeding and drilled with the seed. Weeds, diseases and insects were controlled by chemical sprays as necessary.

^{P} denotes Plant Breeder Rights

Results

Cultivars did not consistently differ in their yield response to added nitrogen or increasing plant density. Of the seven trials conducted between 2015 and 2016, there were few interactions between cultivar and management. At East Koorda in 2016, there was a two way interaction of cultivar with nitrogen (Table 1), there was a two way interaction of cultivar with plant density at Moorine Rock in 2015 and Binnu in 2016 (Table 1), and there was a three way interaction of cultivar and nitrogen with plant density at Yuna in 2015 where head frost occurred.

Effect of nitrogen on wheat grain yield

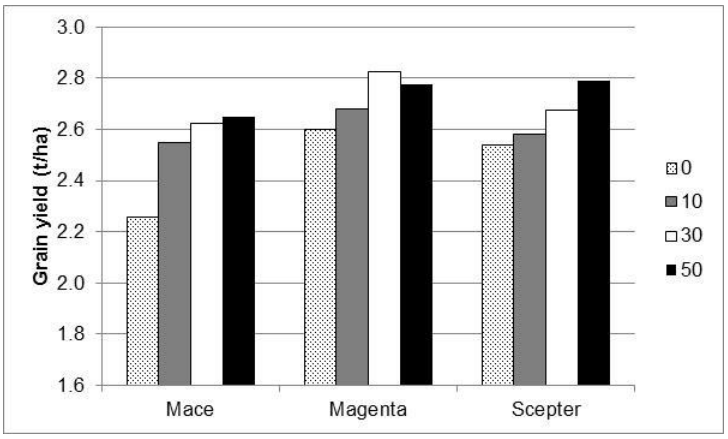
At East Koorda in 2016 cultivars differed in their response to nitrogen. Magenta and Scepter had significantly higher grain yields than Mace with no applied nitrogen (Figure 1a). Grain yield of all cultivars increased significantly with 30 kg N/ha applied at seeding. Scepter yields were significantly higher with 50 kg N/ha than 30 kg N/ha. Yields of the other cultivars did not differ significantly between 30 and 50 kg N/ha. Cultivars differed in ear number response to increasing nitrogen application at East Koorda in 2016. Magenta and Mace produced significantly more ears than Scepter at 50 kg nitrogen per hectare (Figure 1b). Since

Magenta and Scepter yielded similarly at 50kg/ha of nitrogen, other factors such as grain number per ear and grain size will have influenced how the cultivar achieved its yield.

Table 1 Significance value of factors on grain yield response of wheat cultivars in seven trials (2015-16).

Factor	2015 Yuna	2015 Holt Rock	2015 East Koorda	2015 Moorine Rock	2016 Binnu	2016 East Koorda	2016 Grass Patch
'Cultivar'	**	*	ns	*	*	ns	ns
'Nitrogen'	**	**	**	ns	**	**	**
'Density'	**	**	**	**	ns	**	**
'Cultivar.Nitrogen'	**	ns	ns	ns	ns	*	ns
'Cultivar.Density'	**	ns	ns	*	*	ns	ns
'Nitrogen.Density'	*	*	ns	ns	ns	ns	ns
'Cultivar.Nitrogen.Density'	**	ns	ns	ns	ns	ns	ns

Note- Density: target plant density sown



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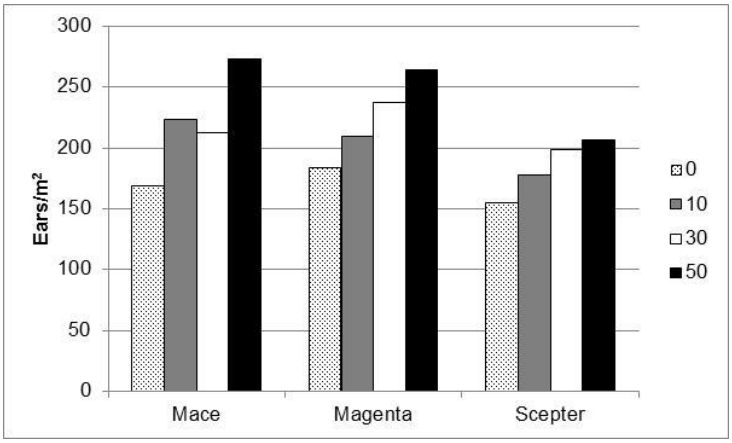

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Figure 1 Influence of increasing nitrogen applied (kg/ha) on a) grain yield and b) ear numbers (at target plant density of 120 plants/m^2) of three wheat cultivars sown at East Koorda in 2016 (LSD $_{YLD}$ (0.05) =0.29 between cultivar, 0.20 within cultivar) (CV=8.7%); LSD $_{ear}$ (0.05) =26 between cultivar, 20 within cultivar) (CV=10%)

Plant density affects wheat grain yield

There was a significant main effect of density on grain yield in all experiments except Binnu in 2016 (Table 1). At East Koorda (2015 and 2016), Holt Rock (2015) and Grass Patch (2016) densities of 50 plants/m^2 were significantly lower yielding than densities above 100 plants/m^2 (Figure 2). This increase in yield accounted for additional seed sown. Further increases in plant density above 150plants/m^2 did not significantly increase yield. However densities greater than 200 plants/m^2 can significantly increase crop competition against weeds in this environment (Lemerle D etal 2004).

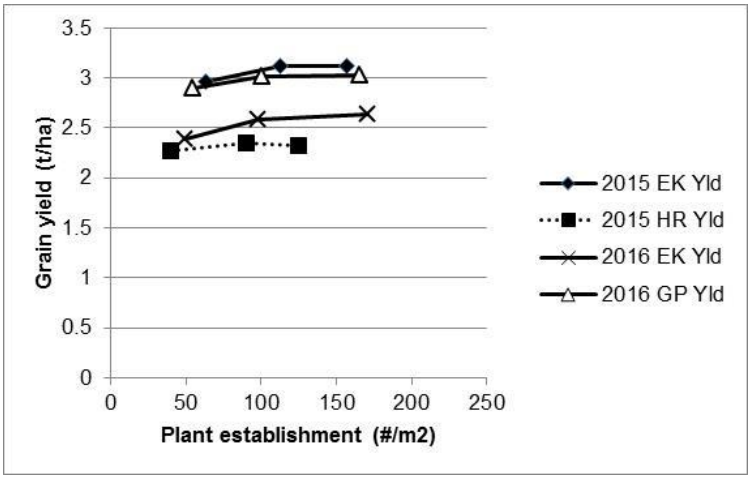
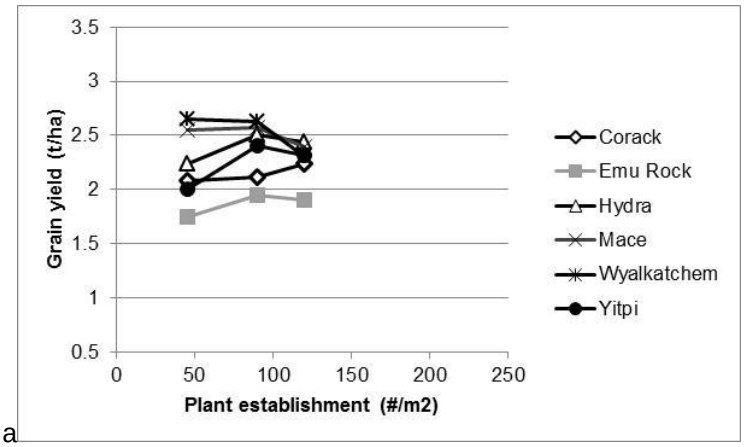


Figure 2 Influence of increasing plant density on wheat yields (averaged across cultivars and nitrogen rates) at East Koorda in 2015 and 2016 and Holt Rock in 2015 and Grass Patch in 2016. East Koorda 2015 (LSD $_{YLD}$ (0.05) =0.09, CV=8.7%) and 2016 (LSD $_{YLD}$ (0.05) =0.07, CV=8.5 %); Holt Rock (LSD $_{YLD}$ (0.05) =0.04, CV=5.5%) and Grass Patch(GP) LSD $_{YLD}$ (0.05) =0.09, CV=9.7%.

Yield response to increased plant density did not differ between cultivars in 4 of the 7 trials located in lower rainfall environments (Table 1). However in two trials, Moorine Rock in 2015 and Binnu in 2016, there was a cultivar interaction with density. Mace yields declined by 200 kg/ha with increasing density from 50 to 230plants/m^2 at Binnu while the yield of other cultivars did not change (Figure 3b). At Moorine Rock, yields of both Wyalkatchem and Mace did not respond to increasing density from 50 to 90plants/m^2 but declined with a further increase to 120plants/m^2 (Figure 3b) whereas yields of the other cultivars increased significantly when plant densities increased from 50 to 100plants/m^2 and showed no further yield increase at 120plants/m^2. Plant establishment was lower than expected at Moorine Rock and soil nitrogen was very high (calculated at over 500kg/ha to 60 cm). This environment is unique and may influence the different responses of varieties to increasing plant density to 120plants/m^2.



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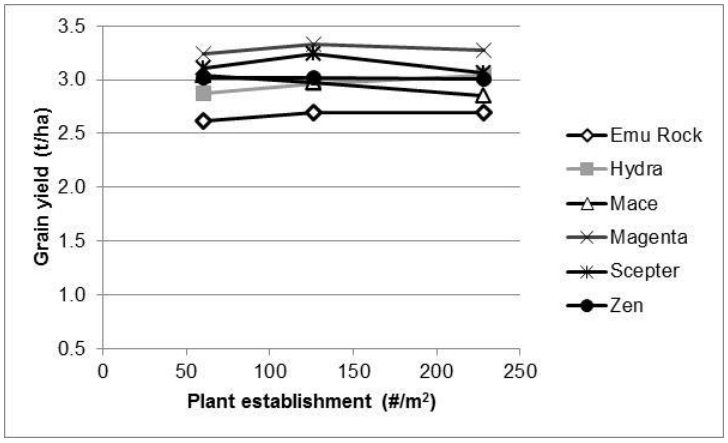

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Figure 3 Influence of increasing plant density on wheat yields (averaged for cultivar and nitrogen) at a) Moorine Rock in 2015 and b) Binnu in 2016. Where Moorine Rock (LSD $_{YLD}$ (0.05) =0.44 between cultivar (0.24 within cultivar), CV=12.8%) and where Binnu (LSD $_{YLD}$ (0.05) =0.32 between cultivar (0.12 within cultivar), (CV=5.5%)

Protein

The season, timing of nitrogen and rate applied are factors which will have influenced protein response to added nitrogen. Protein levels were low in both 2015 and 2016, ranging from 8.7 to 9.7% with 50kg/ha nitrogen applied. However at two sites, protein levels in the grain were greater than 10%. The Yuna site in 2015 was frost affected and soil nitrogen at Moorine Rock was calculated to be in excess of 546kg/ha to depth.

Screenings

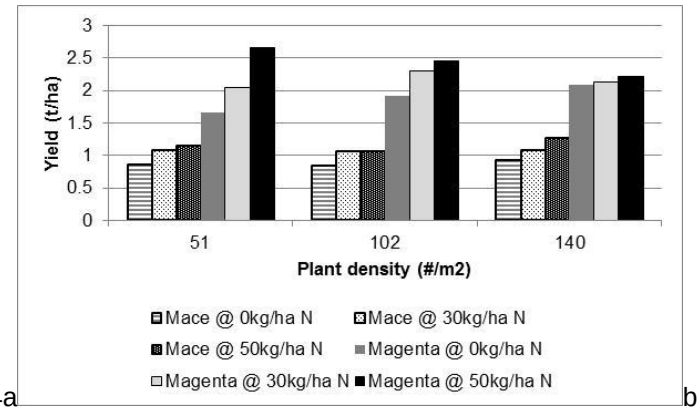
Small grain screenings were not influenced by changing plant density or increasing nitrogen. Increasing plant density to 200 plants/m^2 and applying 50 kg N/ha did not significantly increase small grain screenings above the industry standard of 5% in 6 of 7 trials. However at Moorine Rock, Hydra and Yitpi had screenings above 5%. Sowing mid-long maturing wheat cultivars, such as Yitpi, in low rainfall environments increases the screenings risk. The 1000 grain weight of Hydra and Yitpi were 27 and 28g respectively (averaged over densities and nitrogen rates), significantly lower than other cultivars at the site which ranged from 35 – 41 g per 1000 seeds. Growers should consider higher plant densities for weed control options because there is no consistent evidence that increasing density to 200plants/m^2 will increase screenings and affect economic returns.

Yuna 2015

Head frost occurred at Yuna in 2015 which influenced yield response. There was an interaction between density, nitrogen and cultivar for yield. Yields of Mace (short-mid maturity) were significantly lower than Magenta (mid-long maturity). At 50plants/m^2, Magenta responded to 50 kg/ha of added nitrogen with a 1 t/ha yield increase above the nil treatment (Figure 4a). At 140plants/m^2, Magenta did not response to added nitrogen. Mace yields increased by 0.3 t/ha with up to 50 kg/ha of applied nitrogen at both the low and high plant densities. Grain yield responses at Yuna were significantly lower than potential yield (Appendix 1).

Ear numbers were influenced by applied nitrogen and increasing density. At low densities, ear numbers of both Magenta and Mace were similar and increased by approximately 40 ears/m^2 when applied nitrogen increased from 30 to 50 kg/ha. However at high density they were not significantly affected by added nitrogen (Figure 4b).

Significant frost events were reported in the region in this year and the paddock surrounding the trial was also affected by frost. In the trial, hectolitre weights were below industry standards for the cultivars Corack, Mace and Supreme but not Calingiri, Magenta or Zen (data not shown). This suggests the short-mid maturing varieties were significantly affected by frost, however frost induced sterility was not measured. Magenta's yield was close to double the yield of all other cultivars at this site. Cultivar maturity influenced yield more than plant density.



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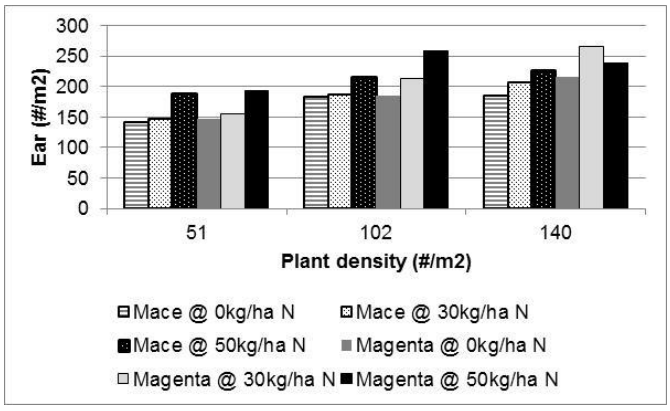

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Figure 4 Influence of applied nitrogen (kg/ha) and actual plant density on a) grain yield (t/ha) and b) ears/m^2 of Mace and Magenta wheats sown at Yuna in 2015 (LSD_{YLD} (0.05) =0.45 between cultivar, 0.20 within cultivar) (CV=9.5%); Yuna (LSD_{EAR} (0.05)= 95 between cultivar, 33 within cultivar) (CV=10.8%)

Conclusion

The hypothesis that cultivars differ in their response to increasing nitrogen up to 50kg/ha or plant density up to 200plants/m^2 was not supported. In a single environment, different cultivars responded to changes in density or applied nitrogen similarly in most of trials. Differences in cultivar response were only observed when some aspect of the environment was unusual, such as head frost at Yuna in 2015 and very high background N coupled with a dry finish at Moorine Rock in 2015.

Plant densities less than 100 plants/m^2 will limit production when sown in early to mid-May. There is no consistent evidence that increased density to 200 plants/m^2 will significantly affect grain yields or increase small grain screenings.

Cultivar maturity variety influenced yield more than plant density at the site which experienced frost damage.

Key words

Wheat, 'plant density', seeding rate', nitrogen.

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Appendix

Appendix 1 Site details (location, rotation, soil type, sowing date, rainfall and potential yield) for research trials conducted in 2015 and 2016.

Location (in a year)	Rotation	Soil type	Soil nitrogen[A]	Sowing date	Rain (mm) (Jan- April)	Rain (mm) May- Oct	Total Rain (Jan – Dec)	Potential yield[B] @ 110mm evap	Potential yield @ 80mm evap	Site Mean (t/ha)
2015										
Yuna	Canola	Sandy earth	63	13-May	166	205	372	2.3	2.7	1.1
East Koorda	Fallow	alkaline red shallow loamy duplex	64	13-May	123	238	360	2.5	3.0	3.1
Holt Rock	Canola		124	Dry sown 1st May. Effective date 16 May after 20mm rain	64	152	216	0.9	1.4	2.3
Moorine Rock	Fallow	alkaline red shallow loamy duplex	546	14-May	113	192	306	1.8	2.2	1.9
2016										
Binnu	Canola	Sandy earth	34	2-May	93	257	350	2.7	3.1	3
East Koorda	Canola	alkaline red shallow loamy duplex	98	5-May	157	200	258	2.1	2.6	2.5
Grass Patch	Canola	Loamy duplex	85	16-May	29	229	258	1.9	2.4	3

Note: A: calculated nitrogen to 60cm (kg/ha); Note: B: Potential yield was calculated using the expression, 'PY = [(one third of summer rain (mm) plus growing season rainfall (May- Oct) minus evaporation (mm))' multiplied by 20kg grain per mm of rain).

Reference

Lemerle D, Cousens R D, Gill G S, and Peltzer S J (2004). Reliability of higher seeding rates of wheat for increased competitiveness with weeds in low rainfall environments. Journal of Agricultural Science 142: 395-409.