Harvest Index of Plants Which Differ in Spike Number in Response to Nitrogen

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ABSTRACT

The effect on crop performance of variation in spike number per plant within the crop, is poorly understood. The harvest index (HI) of plants with different spike number was measured from two nitrogen experiments, one of which was irrigated from anthesis. There were few significant differences in whole-plant HI between plants of different spike number or nitrogen treatment, and few significant differences in plant mass between nitrogen treatments. Spikes from tillers had lower HI than main spikes, but on plants with more tiller spikes, tiller spike HI increased at high nitrogen to compensate for their greater number. This is likely to be because early tillers on plants with more tillers were more like the main stem, than on plants with few tillers. If these results, from plants differing in spike number because of combined effects of plant density and nitrogen, can be extended to changes in plant density, increasing HI by reducing the proportion of tiller spikes, is unlikely to be successful.

KEY WORDS

Harvest index, spike number, grain number, nitrogen.

INTRODUCTION

A useful in-season crop simulation model would complement the sophisticated grain marketing techniques being adopted by farmers. Many crops display large within-crop variation in the number of spikes per plant, and a better understanding of the impact of this variation on crop yield may aid the development of such models. The issue of plant spike number is also relevant to debates about sowing rates and reduced tillering wheats. In this paper, the effect of number of spikes per plant on HI is investigated in crops supplied with various rates of nitrogen in two Wimmera environments.

MATERIALS AND METHODS

Wheat (cv. Rosella) was sown in field experiments in the Wimmera in 1998, supplied with 0, 35, 70 and 70/50 kg of nitrogen as urea pre-drilled at sowing/broadcast at heading, four replicates. Differences in sowing time and irrigation were used to create two environments, *CoolDry* (sown 18 June, 192 mm growing season rainfall) and *CoolWet* (sown 14 July, 207 mm growing season rainfall + full profile irrigation at anthesis). Ten 0.5 m quadrats (approx. 200 plants) were randomly harvested from the centre five rows of each (13 row) plot at maturity, and plants separated into categories by spike number per plant and main/tiller spikes. Infertile tillers were bulked with the tiller spikes, or kept separate on single spike plants. Biomass, grain yield and grain weights (fresh weight basis) were measured on each spike number x main/tiller sample.

RESULTS

Whole plot yields

There was a yield and protein response to nitrogen at *CoolDry*, and a protein response to nitrogen at *CoolWet* (data not shown). The yield response in *CoolDry* was a product of increased spike and hence grain number, with lesser grain weight.

Stem dry weight and harvest index

Multi-spike plants had significantly higher main stem mass than single spike plants in both environments (data shown for *CoolDry* in Table 1). Each additional tiller was associated with a similar amount of increase in plant dry matter, number of spikes per plant and nitrogen treatment having no effect for plants with more than two spikes in either environment. There were no significant differences between main stem HI, caused by the number of spikes per plant. Tiller spike HI tended to increase with number of spikes per plant at high nitrogen, in both environments. Changes in whole plant HI tended to parallel those of the main stem, increasing with nitrogen in *CoolDry* and decreasing in *CoolWet*. There were few significant differences in whole plant HI with either number of spikes per plant or nitrogen.

Table 1. Harvest stem mass, whole plant mass and harvest index of plants with different spike number under different nitrogen treatments in *CoolDry*.

Nitrogen	Spikes	Main Stem		Tillers		Whole Plant	
	Per plant	Mass/Spike	Harvest Index	Mass/Spike	Harvest Index	[1]Mass/Plant	Harvest Index
	No. (%)[3]	(g) ? Sem	(g/g) ? Sem	(g) ? Sem	(g/g) ? Sem	(g) ? Sem	(g/g) ? SEm
0N	1 (66%)	2.71?0.06a	0.350?0.009			2.86?0.06a	0.331?0.009
	2 (31%)	2.94?0.05b	0.344?0.009	1.82?0.04	0.329?0.003	4.76?0.09b	0.338?0.006
	3 (3%)	2.83?0.12ab	0.314?0.027	1.67?0.08	0.247?0.076	6.17?0.22c	0.281?0.033
35N	1 (53%)	2.53?0.05a	0.349?0.002			2.71?0.05a	0.326?0.002
	2 (39%)	2.76?0.05b	0.356?0.007	1.62?0.01	0.320?0.011	4.37?0.04b	0.343?0.007
	3 (8%)	2.94?0.13b	0.362?0.009	1.56?0.07	0.317?0.014	6.01?0.24c	0.339?0.011
70N	1 (51%)	2.40?0.06a	0.365?0.003			2.56?0.07a	0.343?0.003

	2 (37%)	2.76?0.01b	0.363?0.011	1.55?0.05	0.305?0.011a	4.30?0.05b	0.342?0.007
	3 (11%)	2.81?0.04b	0.358?0.009	1.60?0.04	0.345?0.008b	6.00?0.10c	0.351?0.006
	4 (1%)	2.92?0.23ab	0.333?0.054	1.95?0.20	0.331?0.047ab	8.77?0.82d	0.332?0.049
70/50N	1 (42%)	2.50?0.08	0.374?0.007			2.67?0.08a	0.350?0.006ab
	2 (46%)	2.72?0.02	0.363?0.005	1.59?0.04	0.310?0.003	4.29?0.06b	0.344?0.003ab
	3 (11%)	2.76?0.10	0.359?0.012	1.52?0.07	0.322?0.005	5.74?0.22c	0.340?0.006a
	4 (1%)	2.80?0.11	0.398?0.011	1.75?0.08	0.373?0.024	8.06?0.17d	0.382?0.016b
[2]LSD	1	0.17				0.18	
	2	0.13		0.12		0.20	

1. The discrepancy between main stem and whole plant mass and HI for single spike plants is due to infertile tillers, which were weighed separately from the main stem, but are not included as 'tillers' for clarity.

2. Means for different spike numbers within each nitrogen treatment were compared for all variates, by calculating the confidence interval (200 bootstrap replications) of the difference between the mean for each spike number. If it did not include zero, the difference was considered significant. Significant differences have different letters.

3. Average proportion of plants with that spike number per plant.

DISCUSSION

There were few instances where HI of whole plants was significantly different with either changes in nitrogen or spike number. This suggested that any arrangement of plants with a given biomass would give the same yield in the conditions of this experiment. This was not intuitive, because tiller spike HI were significantly lower than main spike HI. However, tiller spike HI increased with tiller number at high nitrogen, so whole plant HI was not reduced. Plants maintained grain number per spike as the number of tillers increased (data not shown), so plants which tillered probably had the resources to produce bigger spikes on early tillers, compared with two- spike plants. This would result in no net difference with more tiller spikes. Once the infertile tillers were added into single plant biomass, there was no net difference in HI with number of spikes per plant.

These results are further evidence of the ability of plants to allocate resources in a consistent way, despite local variation in the environment. Plants in this experiment appeared to have different spike number because of the combined effects of nitrogen and density (data not shown). If these results can be extended to changes in plant density, increasing HI by reducing the proportion of tiller spikes, is unlikely to be successful, and accounting for the number of spikes per plant in crop simulation models is unlikely to improve estimates of yield. However, other measurements on these samples show definite impacts of plant spike number on grain size and protein.

CONCLUSIONS

Tiller spikes have a lower HI than main spikes. Within a crop, the HI of tiller spikes increases with the number of spikes per plant at high nitrogen, so that whole plant HI is not reduced by increasing the number of tiller spikes per plant.